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**CATALOGUE OF THE ODONATA (DRAGONFLIES) OF
THE VICINITY OF PHILADELPHIA, WITH
AN INTRODUCTION TO THE STUDY
OF THIS GROUP OF INSECTS.**

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(Plates II and III).

Such eminent authorities as the Baron de Selys-Longchamps, Prof. Uhler and Mr. McLachlan, have at different times expressed the opinion that the number of species of Dragonflies is decreasing, at least in well-settled districts. The causes for this decrease are probably to be found in the pollution of the waters in which the nymphs live, and the filling up of ponds which formerly served as centres of propagation. Such being the case—and it is also true of other groups of animals—it seems advisable to bring together in permanent form such records as exist of the dragonflies of Philadelphia and its neighborhood, of their times of appearance, and of other biological facts concerning them. While such a descriptive catalogue as the present would be of greater value if it treated of a larger area, yet too large a proportion of the species of the Eastern United States, for instance, remain personally unknown to the writer to render such an extension advisable.

The data upon which the present Catalogue is based are—specimens in the collection of the American Entomological Society, collected chiefly by Mr. S. F. Aaron, and in that of the Wagner Institute of Science by Mr. C. W. Johnson; those gathered by Dr. Henry Skinner and Messrs. C. W. Johnson, Philip Nell and Philip Laurent, and generously placed by them at the writer's disposal; while the principal source has been the writer's own observations made in Delaware County, Pennsylvania, during the Summers of 1886-93. For the years 1888-92, a record was made each day for each species observed, but other occupations prevented continuous daily observations, so that future observers will probably add much to the facts here given.

The scope of this Catalogue is set forth on page 266. In defining the major groups and the genera, the endeavor has been to so state their respective characters as to separate them from all other groups of like rank wherever found, and not merely with reference to North American forms. While not as much can be claimed for the specific definitions, yet there, too, a similar attempt has been made; these throughout have been newly drawn up from specimens, except in the few cases noted in the text where such were not available. Only selected references to previous descriptions of species are given, in view of the existence of the synopses of Dr. Hagen and Mr. Banks. The classification of the Calopteryginae, Agrioninae, Gomphinae and Cordulinae follows very nearly, although often in reverse order, the latest published views of Baron de Selys, and of the Aeschninae, those of Dr. Karsch, while a new arrangement of the Libellulinae has been employed.

The distribution of each species is given in full, and the information on this subject will, in many cases, be found to greatly exceed that already published. That it has been possible to do this is owing to the labors of collectors who have submitted their specimens to the writer for examination, and whose results have not, save in two or three cases, been published. Such are the collections made by Miss Mattie Wadsworth, at Manchester, Me.; Mrs. A. T. Slosson, at Franconia, N. H., and in Florida; Miss A. M. Sharp, in Tama Co., Iowa; by Messrs. J. P. Moore, at York Harbor, Me., Lake St. Regis, N. Y., and with D. J. Bullock, in the Bahamas; Prof. F. L. Harvey, at Orono, Me.; W. Sheraton, Pictou, N. S.; P. C. Truman and E. S. Cheney, S. Dakota; Prof. E. T. Owen, Dane Co., Wis.; J. F. Schafer, Mt. Pulaski, Ill.; F. S. Jones, Chincoteague and Assateague Is., Va.; E. V. Beales, Denver, Col.; G. D. W. Williamson, Dobb's Ferry, N. Y.; C. C. Adams, Bloomington, Ill.; A. L. Babcock, Sherborn, Mass.; T. D. A. Cockerell, Las Cruces, N. Mex.; A. Davidson, M.D., Los Angeles, Calif.; W. D. Richardson, Fredericksburg, Va.; H. L. Walker, Belvidere, Ill.; G. Miller, York, Pa.; Prof. O. B. Johnson, Seattle, Wash.; F. H. Hillman, Reno, Nev.; W. J. Fox, Jamaica; E. F. Hitchings, Worcester, Mass.; C. W. Johnson, Dover, N. J., and Great Wicomico River, Va.; Michigan and Colorado Agricultural Colleges; and by the writer in the White Mts., N. H., Saratoga, N. Y., and Sea Isle, N. J.

From time to time the writer has been requested to name such books as would serve as introductions to the study of this group of

insects. It has not been possible to answer such questions satisfactorily, owing to the lack of any work, in English at least, which treated of the structure and development of the Odonata, save in a brief and general way. Part I of the present paper is intended to supply this deficiency, and, by mentioning those topics on which present knowledge is insufficient or wanting, to suggest subjects for investigation. It has been taken for granted that those who will use it are already acquainted with the structure of insects in general and the technical terms used in connection therewith, to at least the extent contained in the introductory chapters of Comstock, or of Packard, or in the papers on "Elementary Entomology" contributed by the writer to *Entomological News* from May, 1890, to April, 1891; and in treating of the embryonic development a knowledge of the elementary facts of embryology is presumed. While free use has been made of the existing literature in its preparation, by far the larger portion of Part I is based on personal dissections, and some details are introduced which are believed to be new, *e. g.* the descriptions of the cephalic muscles (pp. 171-2), main tracheæ (p. 179), development of the skeleton of the nymph (pp. 195-8), and the view of the phylogeny of the subfamilies (pp. 211-214).

The writer is indebted to his brother, Mr. Frederic B. Calvert, for the table on page 208. As stated in the text, this table is based on Mr. Kirby's Catalogue, but it is highly probable that many of the species contained therein will hereafter prove to be mere varieties, so that the figures in the table rather overstate the facts.

Valuable aid has been rendered by Mr. Chas. W. Johnson in supplying specimens and dates; by Dr. G. H. Horn, in comparing specimens of *Diplax* with the types in the Museum of Comparative Zoology at Cambridge, Mass.; by Mr. Samuel Henshaw, in a similar way for *Aeschna clepsydra* and *Libellula exusta* in the same museum; while Mr. H. F. Moore opportunely presented the nymph of *Calopteryx maculata* (afterwards raised to an imago) figured in part on Plate II, fig. 8.

Fig. 2 is after Walsh, figs. 33 and 34 are copied from Korschelt and Heider's *Lehrbuch*; all the others are original.

Biological School,
University of Pa.,
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PART I.

A GENERAL ACCOUNT OF THE ODONATA.

NAMES AND DEFINITION.

The insects technically known as the Odonata have received the popular English names of Dragonflies, Darning-needles, Bad-man's-needles, Devil's darning-needles, Snake doctors, Mosquito hawks and Horse-stingers. Some of these names testify to that widespread, but quite unfounded belief in the harmfulness of these creatures to man, which is by no means yet extinct.

Philip Andreas Nemnich, in his Allgemeines Polyglotten-Lexicon der Naturgeschichte, article Libellula, has brought together many popular names of the dragonfly in various languages, especially from the German. A selection is added: German, *Wassernympfe*, *Wasserjungfer* (water maiden); French, *demoiselle*; Spanish, *Nadadora*; Portugese, *Mosca que da grandes picadas* (fly with the great stings); Italian, *Cevettone*, *Saetta* (arrow); Dutch, *Juffer*, *Scherpstekende vlieg* (sharp-sticking-fly) (McLachlan); Danish, *Guldsmed*; Swedish, *Trollslanda*.

In the classification of Linnæus, the dragonflies appear as the genus *Libellula* of the order Neuroptera. Fabricius was the first to apply to them the name *Odonata** (Ent. Syst. ii, p. vi, 373, 1793), to designate his fifth 'Classis' of the Insecta. Subsequent writers have variously regarded the group as a family or as a suborder, either of the Neuroptera or of the Pseudoneuroptera, retaining the Fabrician name. Still other, and for the most part later authors regard the Odonata as an order of the Ametabolous, Hemimetabolous or Homomorphous series of Insects.

The zoological characters of the Odonata are:

Insects with an incomplete metamorphosis. Alimentary canal without cæca. Seven pairs of abdominal ganglia. Malpighian tubules numerous (50-70).

Imago.—Head of conspicuous size, its prothoracic articulation very mobile; antennæ short, awl-like (subulate); eyes large; three ocelli; biting mouth-parts, labium proportionately large. Prothorax

* Greek ὀδους, ὀδοντος (odous, odontos), a tooth, referring presumably to the toothed mandibles.

much smaller than the other two thoracic segments, which are closely united to each other; tarsi of three joints; wings large, flat, membranous, many-veined, of nearly equal length, furnished with an opaque pterostigma on the front margin near the apex. Abdomen of ten distinct and one anal segment, terminated with a pair of unjointed, dorsal appendages. Males with the external opening of the testes on the ventral surface of the ninth abdominal segment, penis and accessory genital organs on the ventral surface of the second segment, and one or two terminal, inferior, abdominal appendages. Females with the vulva at the ventral apex of the eighth abdominal segment, no inferior, terminal abdominal appendages.

Nymph (i.e. the form from egg to imago) aquatic; labium (mask) of large size, protractile, and functioning as a seizing organ. Respiration by tracheal gills.

The divisions here recognized are:

Order ODONATA.

Suborder Zygoptera.

Family Agrionidæ.

Subfamily Calopteryginæ.

Subfamily Agrioninæ.

Suborder Anisoptera.

Family Aeschnidæ.

Subfamily Gomphinæ.

Subfamily Cordulegasterinæ.

Subfamily Aeschninæ.

Family Libellulidæ.

Subfamily Cordulinæ.

Subfamily Libellulinæ.

They are defined in Part II.

1. STRUCTURE OF THE IMAGO.

THE SKELETON.

The most prominent external features of the Odonata are the large size of the head and its distinctness from the rest of the body, the compact thorax bearing the powerful and many-veined wings, and the length and slenderness of the abdomen.

Of the **head** (Pl. II, fig. 11), by far the most conspicuous parts are the *eyes*. Even in those forms (Agrionidæ) in which they occupy the relatively smallest area of the head, their proportionate size is only occasionally equaled in other groups of animals. In all

the Odonate groups, the eyes occupy the lateral parts of the head, being mainly restricted to that region in the Agrionidæ, and there the head is transversely elongated; reaching farther towards the mid-dorsal line in the Gomphinæ, meeting at a single point on the top of the head in the Cordulegasterinæ; finally, in the Libellulidæ and the Aeschninæ being connected for at least some little distance, and here the head is globose. It is in various genera of the Aeschninæ that their connection is proportionally greatest, and the eyes themselves relatively largest, and these same genera include those species whose flight is most powerful.

The facets are hexagonal in shape, and where the eyes meet dorsally, those of the upper surface are larger than those of the lower. In such cases a gradual transition in size from one to the other exists, but in many Libellulinæ the facets of about the upper third of each eye are distinctly marked off in size from the lower ones, the line of separation being nearly horizontal. Below this line a gradual difference in size downwards is found. In life the color of the eyes is darker above and becomes paler below.

The *epicranium* occupies a very large part of the area of the head. In the Agrionidæ, it completely separates the eyes from each other, but is itself divided into right and left halves except at the vertex, frons, and for a short distance above the posterior foramen. This division is made—beginning at the frons and proceeding forwards, downwards, backwards and upwards—by the clypeus, labrum, mouth parts, gula, posterior foramen and occiput. The occiput, however, although distinct in the Anisoptera, appears to be so completely fused with the epicranium in the Zygoptera that no sutures are visible.

Names have been applied to different parts of the epicranium. The most dorsal portion, and especially the region of the ocelli, is the *vertex*. Between the vertex and the clypeus is the *frons*; the place of insertion of the antennæ may be considered to mark its posterior boundary. Since each eye is encircled by epicranium, that portion lying between the eye and the clypeus and mouth-parts is the *gena*. Lastly, the hindmost part of the head is simply referred to as the *rear of the head*, or the *rear of the eyes*; the right and left halves of this part unite with each other above the posterior foramen and below the occiput, but the uniting suture is usually obliterated. On either side of the posterior foramen is a groove in which glides a tubercle of the prothorax to furnish the articulation of head and thorax.

The preceding description of the parts of the epicranium applies to the Agrionidæ and the Gomphinæ, except that in the latter the occiput is separated by distinct sutures in front and on either side, but behind it fuses with the epicranium. In the remaining groups, where the eyes meet in a greater or less extent on the top of the head, the area of the epicranium is much reduced. Little remains of the vertex, except that part included between the ocelli, which is elevated and often characteristically shaped in different genera; it is the *frontal vesicle* of some authors. The genæ are almost entirely obliterated. The frons is bent on itself at an obtuse angle so that two surfaces may be distinguished, one horizontal (superior surface), the other more or less vertical (anterior surface). Behind the eyes the epicranium continues to occupy a considerable area.

The *ocelli* are three in number, placed upon the vertex in the form of an isosceles triangle with its apex directed forwards. The anterior ocellus is the largest of the three.

The *occiput* is situated at the upper, median, posterior portion of the head from the vertex backwards and downwards to a short distance above the posterior foramen, which latter it does not reach. As already mentioned, it is entirely fused with the epicranium in the Zygoptera, but is more or less distinct in the Anisoptera. It presents two more or less distinct surfaces, one dorsal, the other posterior; where these are sharply separated, as in the Gomphinæ, the separating margin (referred to as "hind margin," or simply "margin") frequently offers specific characters.

The *gula* is membranous and extends from the posterior foramen to the submentum.

The *clypeus* (*epistoma*) is wider than high. A division into *ante-* (*infra-*) and *post-* (*supra-*) *clypeus* exists, the former having received the special name of *rhinarium*, the latter that of *nasus*; they form an obtuse angle with each other in the Zygoptera, but lie more nearly in the same plane in the Anisoptera.

The *labrum* is of moderate size, elongated horizontally, its basal margin nearly straight, its free edge rounded.

The *antennæ* are quite short, bristle-like, and are inserted on the epicranium between frons and vertex. Each consists of at least four joints, of which the basal is usually thickest and shortest. The remaining joints successively decrease in thickness, their comparative length varies in different genera.

The *mandibles* are moderate in size, but strong, and toothed on the inner (opposed) surface. The apex ends as a sharp point, on both anterior and posterior sides of which is an acute tooth. Separated by an interval from this apical group of teeth, is a toothed basal portion, suggesting, as Rambur remarked, a molar. In surface view, this is a **Z**-shaped ridge. If the top of the **Z** be considered to be that lying nearer the apex of the mandible, then the upper angle of the **Z** lies next the anterior surface of the mandible, that is, the **Z** looks backwards. At each of the two angles, and at each of the two free ends of the **Z**, the ridge is elevated into an acute tubercle.

The stem of the *first maxilla* is composed of two joints of which the basal is the *cardo*, the distal, about twice as long, is the *stipes*. Articulated to the distal end of the stipes are two separate pieces, each consisting of a single joint. The outer is much the slenderer, of simple form, clothed with hairs, is curved inwards and backwards, and ends in a fairly acute apex; it is the *maxillary palpus*. The inner piece is flattened from behind forwards; its inner edge bears six long spines and some long hairs; it corresponds to the galea and lacinia (outer and inner lobes of the maxilla) fused together (Gerstaecker 2*).

Various views have been held as to the composition of the *labium* or *second maxillæ*. It will be sufficient to mention only two here. An examination of Pl. II, fig. 7, will be necessary to properly understand the text.

By Rambur (33), and in the earlier writings of Hagen, the median portion of the labium (*ml*, fig. 7) was regarded as representing the inner and outer lobes of the labium, that is a fusion of the glossæ and paraglossæ, while each lateral portion (*ll*) was held to be merely the labial palp.

Gerstaecker (2) holds that *ml* is a fusion of merely the inner lobes (glossæ), while *ll* is composed of a union of an outer lobe (paraglossa) and a labial palp. Graber (Die Insekten I, p. 130, fig. 186) accepts Gerstaecker's view, but piece *s*, which Gerstaecker calls the *squama*, he regards as half of the mentum; hence *m*, the "mittelstück" of Gerstaecker, or *subglossa*, has come to lie between the right and left halves of the mentum.

For the sake of convenience, de Selys' usage will be followed here, and the middle portion, *ml*, be designated as the *median lobe*, and each lateral part, *ll*, as the *lateral lobe*. The median lobe is bifid at its extremity in the Agrionidæ, some Gomphinæ, and the Cordulegasterinæ; it is entire in the other groups, in the Aeschninæ a me-

* These figures after authors' names refer to papers named in the bibliography with which Part I concludes.

dian impressed line recalling the primitively bifid condition. The form of the lateral lobes varies in the different groups, and is proportionally largest in the Libellulidæ. The terminal joint (*tp*) of the lateral lobe of the Agrionidæ, in either of the above views, is the terminal joint of the labial palp; it is also present in the Aeschnidæ, but is wanting in the Libellulidæ.

A *hypopharynx* is present as a median organ of moderate size, hairy, and broader at its free end.

Endoskeleton of the head. Near the centre of the hind surface of the head is a foramen—the *posterior cephalic*—by which the cavities of head and thorax communicate. The foramen is divided by a transverse chitinous rod (*a*) into an upper and a lower half. Through the upper division passes the alimentary canal, vessels, tracheæ, etc., through the lower the ventral nerve cord. From either end of this rod (*a*), where it joins the margins of the posterior foramen, another chitinous rod (*b*) extends forwards and upwards inside the skull to the roof of the head, where frons and vertex meet. Near its lower extremity, rod (*b*) is connected with a chitinous shelf (*c*) which separates the cavity of the frons above from that of the clypeus below. A foramen, whose plane slants from behind downwards and forwards, is thus formed in the centre of the head; its margins are rod (*a*) behind, rod (*b*) on either side, and shelf (*c*) in front. Through this foramen the alimentary canal passes downwards to the mouth, and in so doing, is surrounded by the circumœsophageal nerve-ring. In those groups where the eyes do not meet on the top of the head, the epicranial cavity extends backwards between the right and left orbital cavities, being separated from them by membrane. Where the eyes meet dorsally, the cavity of the epicranium is confined to the front of the head and is made up for the most part by the frons, whose cavity is shut off from those of the orbits by a membrane stretched from one side of the frons to the other and strengthened by the two rods (*b*), and the orbital cavities lie side by side, although separated by an incomplete, superior, chitinous partition.

Of the three segments of the **thorax** (Pl. II, fig. 13) the *prothorax* is much the smallest and least specialized, and is much less intimately related to the mesothorax than the latter is to the metathorax. Its dorsum is transversely divided into three successive areas, called by Rambur, the anterior, median and posterior lobes. The median lobe is usually the largest, and is marked by a longitudinal impression; the front and hind lobes are usually not impressed. The shape

of the hind lobe varies in different species and sexes of the Agrioninæ, and in different genera of the Libellulinæ. The pleura are quite distinct and consist of two or three sclerites. At its anterior edge each pleuron bears a rounded tubercle which slides in a groove on the side of the posterior cephalic foramen. The sternum is of moderate size; the first coxæ are placed near its hind end. Internally, on the floor of the prothorax are two chitinous projections, between which the nerve-cord runs; these, as well as some dorsal, downwardly-directed processes, also serve for muscular attachments.

The remainder of the thorax is characterized by its general obliquity and the close union of meso- and metathorax. The obliquity is due to the great development of the *mesepisterna* which meet each other on the mid-dorsal line, in front of the tergal sclerites of the same segment.* In consequence, the words "dorsum" and "tergum" applied to the thorax have very different meanings. "Dorsum of the thorax," as used by descriptive writers on the Odonata, and as used in this paper, includes the mesepisterna and the meso- and metathoracic terga, that is, all those sclerites which make up the back of the thorax. So, also, "sides of the thorax" is equivalent to the pleura of meso- and metathorax, *less* the mesepisterna. The terga of these two segments taken together are often referred to as the interalar space. Each tergum is made up of scutum, scutellum and post-scutellum, in the Agrionidæ at least, while the præscutum is absent, or at least not externally visible, in the view of Packard (1).

The suture at which the two mesepisterna meet on the dorsum is usually raised into a ridge, the *mid-dorsal thoracic carina* (arete mésothoracique, Rambur). Each mesepisternum terminates on its outer side at the *humeral suture*, present in all Odonata, running from beneath the base of the front wing to the hind edge of the second coxa. A short distance above the second coxa, a transverse suture runs to the anterior opening of the mesothorax, so that a sclerite is formed between the anterior mesothoracic opening on the inside, the humeral suture on the outside, the second coxa below and the transverse suture above—known as the *mesinfraepisternum*.

It is apparently only in the Calopteryginæ that the suture separating meso- and metathorax is complete on the sides of the thorax.

* Such is Packard's (1) view. Walsh (Proc. Ent. Soc. Phila. II, p. 217, 1863) previously advanced the same opinion. Brauer, however, holds (Verhd. k. k. zool.-bot. Gesell. Wien xci, p. 355, 1885), this dorsal part to be mesothoracic præscutum. See the discussion in the text, *post*.

In the members of that subfamily, in front of the metastigma, a suture is to be seen a short distance behind the humeral suture, starting, likewise, from beneath the base of the front wing, and meeting the humeral suture behind the second coxa. This suture is the *first lateral suture* of Rambur, and the space between it and the humeral suture is the *mesepimeron*. Following and parallel to the first lateral suture in the Calopteryginæ is the *second lateral suture*, from beneath the base of the hind wing to the rear of the third coxa. From near its lower extremity a short curved suture passes to the front of the third coxæ, so that a *metinfraepisternum* is formed, corresponding in position to that of the mesothorax. The space between the first and second lateral sutures is the *metepisternum*. Behind the second lateral suture the *metepimeron* extends ventrally to the sternum, with which it is apparently fused in front, but from which it is separated for the most part by the longitudinal *latero-ventral metathoracic carina*.

The mid-dorsal thoracic carina and the first lateral suture thus correspond, and so also the humeral and second lateral sutures.

In some Calopteryginæ (e. g. *Rhinocypha*), and in the other subfamilies, the greater part of the first lateral suture is obliterated, only the lower part up to about the level of the metastigma, and sometimes the upper extremity (e. g. *Lestes*), remaining. Thus mesepimeron and metepisternum form a single piece.

The interpretation of the thoracic pleura here given, which is essentially that of Packard (1), as against those of Brauer and Walsh, seems justified by the metameric arrangement of the wing muscles. Brauer (*l. c.*) holds that what are above regarded as the mesepisterna are really the prescutum of the mesothorax. An examination of the wing muscles (see the description, *post*, and Pl. II, figs. 12, 13), will show that both as regards its relation to the other pleural sclerites, and to the position and origin of the muscles of the front wing, the mesepisternum is the homologue of what is above termed the metepisternum.* Walsh, however (Proc. Ent. Soc. Phila., II, pp. 269, 270), regarded the division between meso- and metathorax as marked by the second lateral suture, while the first lateral suture he termed "false," or "supernumerary." To this it may be replied that the position of the first lateral suture corresponds to the line of separation between the muscles of front and hind wings, the arrangement of which muscles is so clearly metameric (fig. 12, being that of an *Aeschna*, cannot show the first lateral suture as it is obliterated).

The *mesosternum* is relatively small, and lies between and in front of the second coxæ. The *metasternum* is probably all that area

* Compare also the development of the mesepisterna, *post*.

lying between the right and left latero-ventral metathoracic carinæ, and extending from the first abdominal sternum to between the third coxæ.

Internally, at each of the sutures separating the pleural sclerites, is a chitinous ridge (*apodeme*), resulting from an infolding of the integument, to serve for muscular attachment. A development of apodemic processes and the fusion thereof, forms, on the floor of the mesothorax and of the anterior part of the metathorax, a tunnel (*neural canal*) for the ventral nerve-cord.

The pattern of the external coloring of the thorax conforms in the main to the pleural sutures, and by reference to those sutures, the precise location of stripes may be indicated. Thus, very frequently a stripe covers the humeral suture, and is consequently referred to as a "humeral stripe;" an "ante-humeral stripe" is approximately parallel to, but to the inner (mid-dorsal) side of the humeral suture.

Two pairs of spiracles, or stigmata, exist in the thorax. The *mesostigmata* are situated on the lower part of each mesepisternum, close to and somewhat above the margins of the anterior mesothoracic opening; they are often partly concealed by the overhanging of the prothorax. The *metastigmata* lie, one in the lower part of each metepisternum, and are very distinct in all the Odonata.

The *legs* do not present any wide range of variation. Their length successively increases from the first to the third. The second and third are placed closer together than are the first and the second. If the legs be extended in the position natural to the insect when at rest, four faces may be distinguished in the limb—viz.: superior, inferior, anterior and posterior. The terms exterior and interior, as applied by some authors, correspond to the superior and inferior faces, respectively. The coxa is fairly robust and short. The trochanter is longer, constricted near the middle so as to frequently present the appearance of a suture, and its articulation with the femur is oblique. While usually smooth, the trochanter may become spinous (*Gomphus*). The *femur* and the *tibia* constitute by far the greater part of the leg. The former is the stouter and usually the shorter. Both are characterized by the possession of two principal longitudinal rows of downwardly directed, divergent spines, of which one divides the anterior face from the inferior, the other the posterior face from the inferior. The relative size of these spines may be nearly the same on femur and tibia (*Calopteryx*), or those on the

tibia may be much longer (*Aeschna*, *Libellula*). When the spines of both tibial rows are fairly similar in shape, those of the anterior row may be more numerous on the first legs and less numerous on the second and third (*Calopteryx*, *Lestes*, *Libellula*), or more numerous on the first and third and of equal number on the second legs (females of *Cordulegaster*). On the other hand the spines of the anterior row may be replaced by knobs on the second and third tibiae (most males of *Cordulegaster*), or on all the tibiae (males of *Cordulegaster diastatops*). The number of tibial spines, and the relation existing between their length and the intervals separating them, have yielded generic characters in the Agrioninae and Libellulinae. When the femoral spines are shorter than those of the tibia, each of the two primary rows may become a double or a triple row (*Cordulegaster*). Moreover, superior longitudinal rows of spines may be developed on the femur (*Aeschna*), or on the tibia (*Gomphus*). The *tarsus* consists of three joints, increasing in length distally in all living Odonata; the fossil Calopterygine *Tarsophlebia* has the basal joint as long as the second and third joints together. Each joint bears two rows of spines, continuations of those on the tibia. The terminal joint bears a pair of acute, divergent, tarsal nails, each of which has usually an acute tooth on the lower side; the position of this tooth varies in different groups. A minute process occurs between the two nails at their bases.

After remarking the apparently disproportionate size of the legs in an insect which uses them so little for locomotion, McLachlan suggests that "the greatest service all the legs render is possibly in enabling the creature to rest lightly so that it can quit a position of repose in chase of passing prey in the quickest possible manner." (Encyc. Brit. 9th ed. art. Dragonfly). The first pair of legs are usually employed to hold the food as it is devoured.

The *wings* are prolongations of the integument of the meso- and metathorax between the tergum and pleuron. Of the two laminae of which they are formed, the upper is tergal, the lower pleural. The wings are large, membranous and many-veined. The front wings are usually about one millimetre longer than the hind wings; the latter are of equal width with the former at the base, in the Zygoptera, but distinctly wider in the Anisoptera. The arrangement of the veins offers many characters for classification, as well as affording a means for exactly locating wing-markings. Inasmuch as the homologies of the veins in different orders of Insects have not

yet been established, the nomenclature here used will be that of de Selys and Hagen.

At the base of each wing are five large longitudinal veins, whose names, beginning at the front margin, are *costa*, *subcosta*, *median*, *submedian* and *post-costa*. At the basal extremity of the costa is a thickening, the *anterior axillary callus*, and a similar *posterior axillary callus* lies at the base of the median and submedian veins. The structure of the base of the wing and of the adjoining thoracic region has been described and figured by Lendenfeld (4) with a minuteness of detail into which it is not necessary to enter here.

The costa coincides with the front margin of the wings from base to apex; at a varying distance from the base it curves in and then out again forming a wide, but distinct angle. At this point a short, thick cross-vein exists—the *nodus*. Parallel to the costa and next below it is the subcosta, running from the base, but stopping at the nodus, except in a few exotic forms. Below the subcosta and parallel to it is the median vein, the third of those which start from the base of the wing; upon reaching the nodus, it bends upwards towards the costa, next below which it continues to the apex of the wing. Between the median and submedian veins, at the extreme base of the wing is the *basilar space* (*upper basal cell* of Kirby), usually not crossed by veins, and whose apical boundary is a straight or broken cross-vein, the *arculus*. From the apical side of the arculus, two longitudinal veins arise, the *upper* and *lower sectors of the arculus*. The space between the submedian and post-costal veins is the *median space* (*lower basal cell*, Kirby), and the area between post-costa and the hind margin of the wing is the *post-costal space*.

Thus far the description given will apply to all the Odonata. For the further arrangement of the veins, it will be necessary to refer to certain groups separately. If the wing of any North American Odonate, other than a Calopterygine, be examined, it will be seen that the median vein does not give rise to any longitudinal veins, but that four conspicuous longitudinal veins are given off, directly or indirectly, from the upper sector of the arculus. These four veins are from above downwards—1. the *principal sector*, immediately below and parallel to the median vein; 2. the *nodal sector*, which parts from the principal at or near the nodus; 3. the *subnodal sector*, parting from the principal some distance on the basal side of the origin of the nodal; 4. the *median sector* (to be carefully distinguished from the *median vein*), whose point of separation from the principal lies on the basal side of that of the subnodal.

If the distribution of these veins be now compared with that of such a Calopterygine as *Calopteryx* or *Hetærina*, it will be seen that the principal and subnodal sectors apparently arise from the median vein, but a closer examination will show that the principal sector here also arises from the upper sector of the arculus by a short vein which runs from the upper sector (at a short distance from the arculus) obliquely upwards and outwards to the median vein, thence alongside of, and in contact with it, then again separating and continuing on its course as already described for the other groups. The subnodal sector parts from it in the region of its contact with the median vein, while the nodal sector is unchanged. This arrangement of the principal sector does not prevail among all Calopteryginæ; in many exotic genera the positions of principal and subnodal sectors is as described for the order in general, and even some individuals of *Calopteryx* show a complete separation between principal sector and median vein.

De Selys and Hagen have considered the principal vein to extend from the arculus to the apex of the wing, but for the sake of convenience, it is here proposed to regard the principal sector as beginning at the point of its separation from the median sector, and to designate the vein from the arculus to that point of separation, as the upper sector of the arculus.

The lower sector of the arculus is quite constant in position, and runs behind and fairly parallel to the median sector. It is also termed, or at least as much as lies beyond certain areas hereafter described as the quadrilateral or the triangle,—the *short sector*.

The *quadrilateral* is a space on the wings of the Zygoptera, bounded by the lower sector of the arculus, the submedian vein, a cross-vein between these two, and the lower part of the arculus. It may or may not be cross-veined, but in the former case, the cross-vein which forms its outer (distal) boundary is thicker than any of the veins within. Beyond the quadrilateral, the submedian vein is prolonged as the *first* or *upper sector of the triangle*. The post-costa extends outwards below and parallel to the submedian as far as the outer side of the quadrilateral; its prolongation is the *second* or *lower sector of the triangle*.

In the Agrioninæ, Baron de Selys has considered the lower sector of the triangle in some genera as "arising in front of the basal post-costal nervure (see fig. 1)." It would seem more correct, judging from a comparison with the Calopteryginæ, to say "the post-costal vein separating from the hind margin in front of," etc.

In the Anisoptera, an area will be seen occupying nearly the same position as the quadrilateral in the Zygoptera. This is the *hyper-trigonal*, or *supratrangular space*, for the reason that it is immediately above a distinctly triangular area, *the triangle, discoidal triangle, or cardinal cell*. Lying on the basal side of the triangle is frequently another triangular area, the *internal triangle* or *subtriangular space*. The sectors of the triangle arise from or near the lower angle of the triangle; on the outer side of this last between the short sector and the upper sector of the triangle is a varying number of rows of cells—the *post-triangular cells* or *discoidal areolets*.

Between the two families of the Anisoptera a difference exists in the triangle of the front wings. In most Aeschnidæ the triangles of front and hind wings are similar in size and shape. In the Libellulidæ the triangle of the hind wings remains similar to that of the Aeschnidæ with its longer axis parallel to the long axis of the wing, but in the front wings it is elongated from above downwards, so that its long axis is at right angles, or nearly so, to the long axis of the wing.

The lower boundary of the supratrangular space is formed by a vein broken into two parts at the point whence the inner (basal) side of the triangle diverges. Walsh (Proc. Ent. Soc. Phila. II, p. 208) held that of these two parts, the basal one corresponds to the lower side of the quadrilateral of the Zygoptera, the distal part to the outer side of the quadrilateral, and that the supratriangle and quadrilateral are homologous. Consequently the outer side of the triangle would be the homologue of a cross-vein between the short sector and the first of the triangle in the Zygoptera; the upperside of the internal triangle would be the correspondent of the downward prolongation of the apical side of the quadrilateral, while that side of the internal triangle nearest the anal angle would be a portion of the second sector of the triangle of the Zygoptera.

On the other hand De Selys had earlier stated (Mon. Calopt. p. 279, 1854) that the quadrilateral corresponds to the triangle and supra-triangle taken together, and that the distal part of the lower boundary of the supra triangle is a "superior branch of the submedian vein" which is wanting among the Zygoptera. From this view it would follow that the outer side of the triangle is homologous with the apical (outer) side of the quadrilateral, the inner side of the triangle is a part of the lower side of the quadrilateral, and in either view, is a prolongation of the submedian vein and continued by the upper sector of the triangle; finally, the side of the internal triangle nearest the anal angle is a part of the post-costal vein.

The difference between these two views depends upon the homology recognized for the "upper branch of the submedian vein." The view of De Selys is here adopted for the two following reasons:

1. The apical side of the quadrilateral is a convex vein, a condition satisfied by the outer side of the triangle, but not by the "upper branch of the submedian vein."

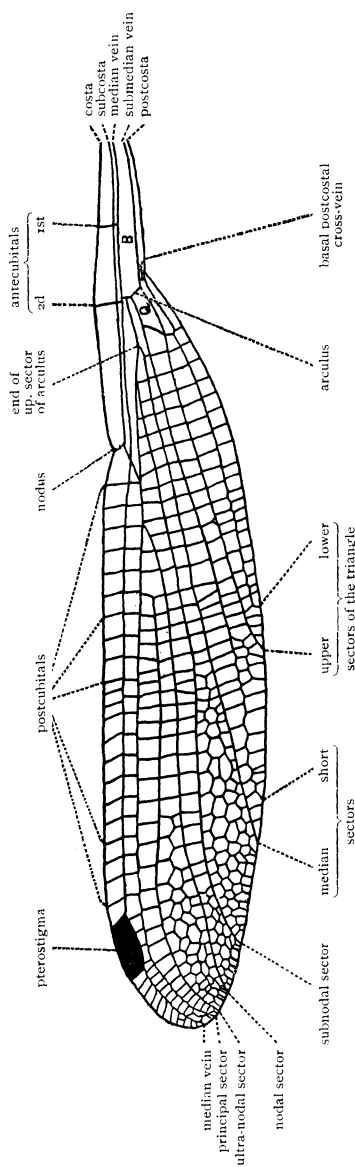


Fig. 1.

Front wing of *Ortholestes clara* Calvert (Ent. News, II, p. 199, 1891), from Jamaica, to illustrate the venation of an Agrionine.

B, basilar space. Q, quadrilateral. Seven antenodal cells are shown. Supplementary sectors are shown between the ultra-nodal and the nodal, the nodal and the subnodal, and the subnodal and the median sectors.

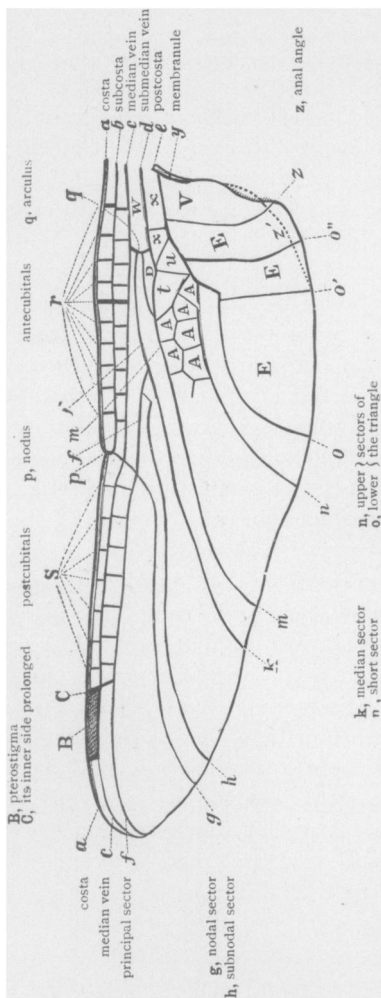


Fig. 2.

Hind wing of a *Gomphus* ♂ (after Walsh).

(By errors in the original engraving the first antecubital of the first series is incorrectly shown as not being entirely coincident with the first of the second series, and the sectors of the triangle ought to have been shown as arising from its lower angle.)

A.....A, three, then two rows of post-triangular cells. D, supra-triangular space. E, E, E, post-costal space. t, triangle. u, internal triangle. V, anal triangle. W, basilar space. x, x, median space. z', dotted line showing outline of anal margin in the female.

2. The wings of the fossil Gomphine genus *Stenophlebia*, as they are figured by Hagen (Paleontographica, X, taf. xiii, figs. 4, 5, 6; XV, taf. xi, fig. 2, taf. xiii, fig. 1) strongly favor such a homology.

The "upper branch of the submedian vein" perhaps arose as a quadrilateral cross-vein which became more and more oblique until it formed the upper side of the triangle, while at the same time the apical (outer) side of the quadrilateral increased in length, carrying the submedian vein and its prolongation, the upper sector of the triangle, farther and farther downwards towards the post-costa and its continuation, the lower sector of the triangle.

The wings are not perfectly flat, but are folded longitudinally* in such a way that the chief veins lie either on the crest of ridges, or at the bottom of valleys (*convex* and *concave* veins of Adolph). Looking upon the *upper* surface of the wings, the costa, median vein, subnodal sector, lower sector of the arculus (short sector) post-costal vein and lower sector of the triangle are convex veins, while the subcostal vein, upper sector of arculus, principal, median and nodal sectors, submedian vein and upper sector of the triangle are concave veins. As Lendenfeld pointed out, this folding of the wings prevents their being bent in a direction at right angles to their surface and a consequent loss of effectiveness as the wings strike the air.

Two characteristic features of Odonate wings are the pterostigma and the membranule. The *pterostigma* is an opaque, colored area between the costa and the median vein near the apex of the wing. It fills usually one cell (*true* pterostigma) or sometimes several cells (*false* pterostigma). It is occasionally absent (some *Zygoptera*), and in one instance present, but not touching the costa (*Anomalagrion*).

The *membranule* is an opaque area at the anal margin, lying outside the veined portion of the wing, absent or rudimentary in the *Zygoptera*, of variable size in the *Anisoptera*.

Of the numerous cross-veins to be found in the wings of the Odonata special names have been applied as follows: *antecubitals* (*antenodals* Kirby) are cross-veins between the costa and median vein, and the base and the nodus, and of which there are two series—those between costa and subcostal, and those between subcostal and median veins; those of the first series may or may not coincide in position with those of the second.

NOTE.—The term *antenodal* or *discoidal cells* has also been applied by deSelys and is used here (see *Enallagma* in the Catalogue, *post*) to denote those cells in the Agrioninae situated between the short sector and the first sector of the triangle, and the outer side of the quadrilateral and the cross-vein which descends from the nodus. They are, therefore, the homologues of the post-triangular cells of the *Anisoptera*, but this distinctive name is convenient.

* This folding is but slight, and does not admit of the wing being closed upon itself, as in the *Orthoptera*, for instance.

Post-cubitals (*post-nodals* Kirby) are cross-veins between the costa and the principal sector, and the nodus and the pterostigma, and of which there are similarly two series.

Basilar, *supra-triangular* and *median cross-veins* cross respectively the basilar, supra-triangular and median spaces. The *basal post-costal vein* (Selys) in the Agrioninæ is a median cross-vein. *Subcostal cross-veins* is the term applied by Karsch to cross-veins confined to the space between subcostal and median veins and on the basal side of the first antecubital.

In addition to the veins and sectors which have already been described, there exist between them near the hind margin of the wing, varying numbers of more or less parallel *supplementary, interposed sectors*. Of these the chief one between the principal and nodal sectors has received the name of *ultra-* or *post-nodal*.

Redtenbacher, in his paper on the wing-veins of insects (Ann. k. k. Naturhist. Hofmus. Wien I, pp. 153-231, 1886), numbers the veins of the Odonate wing as follows: I costa, II subcosta, III₁ median vein, III₂ principal sector, III₃ ultra-nodal sector, IV nodal sector, V subnodal sector, VI median sector, VII short sector, VIII upper sector of the triangle, IX lower sector of the triangle.

While the anal margin of the hind wings is usually convex and the anal "angle" rounded, in the males of many Aeschnidæ and of the Cordulinæ the anal margin is concave, and the angle present. De Selys has shown that this concavity is correlated with the presence of a denticulated tubercle (*auricle*) on either side of the second abdominal segment, and suggests that the hollowing out of the anal margin prevents tearing the wing on the auricular teeth, as would be the result were the anal margin convex. No such concavity of the anal margin is present in the corresponding females, as even when auricles occur in this sex, they are much smaller and not denticulated.

The **abdomen** consists of ten distinct segments, and a terminal tubercle with the anal opening (*anal segment, telson*). It is convenient to designate the abdominal segments from base to apex, by the figures 1 to 10; of these 1 is always the shortest. The exoskeleton of each segment consists of a large dorsal sclerite (tergum), forming an arc much greater than 180°, which overlaps and partly hides the much smaller sternum. Tergum and sternum are connected by a pleural membrane on either side, which allows of the distension and contraction of the segment in the act of respiration. In most of the groups a longitudinal ventral carina is present near each pleural

margin of the terga. In the Aeschninæ and in the Libellulidæ a longitudinal lateral carina is developed on either side of the terga, and distinctly separates the dorsal from the ventral surface of the abdomen. A longitudinal mid-dorsal carina frequently occurs. A transverse carina is present near the base and near the apex of each abdominal segment of most Odonata and, as well as the other carinæ, is frequently denticulated. Additional transverse carinæ occur in some Libellulinæ (*Pantala*, *Tramea*, etc.) and additional longitudinal carinæ in some Aeschninæ (*Anax*). The sternum of the first segment is a simple, usually flat piece, whose lateral margins are more closely united to the tergum than in the succeeding segments. On either side is a stigma (spiracle). The sterna of 2-9 are elongated pieces narrowing posteriorly, having on each side, near the anterior end one or two processes directed outwards and upwards, whereof the anterior is the slenderer. Lying in the pleural membrane, a short distance behind the second lateral sternal process, is a spiracle in 2-8. The sternum of 2 is modified in the males in consequence of the existence of ventral accessory genital organs at that place. The external orifice (*vulva*) of the oviduct in the females is situated at the apex of the sternum of 8, and the posterior margin of that sternum is known as the *vulvar lamina*. The ninth segment has no spiracles; its sternum, in the males, is pierced by a median opening for the vas deferens, which opening is guarded by two small chitinous flaps, one on either side; in the females it is entire, and may be variously bent or grooved in different forms. The sternum of 10 is very small or wanting.

The apex of the abdomen of the males is provided with two *superior*, and one (Anisoptera) or two (Zygoptera) *inferior*, unjointed, chitinous *appendages*, whose function is to clasp the prothorax of the female in copulation and often during oviposition. Their shape is usually characteristic for the species. The cavity of the superior appendages is continuous with that of the tenth segment, to which they belong. The pair of inferior appendages of the Zygoptera belong to the anal segment or telson, the anus opening between them; the single median inferior appendage of the Anisoptera belongs to the same segment the anus lying in a tubercle (anal segment) beneath the appendage.

A secondary sexual modification presented by the males of most Aeschnidæ and of the Cordulinæ, is a pair of protuberances (*auricles*), one on either side of 2, and which are usually denticulated.

Correlated with their presence, as already mentioned, is the excavation of the anal border of the hind wings. In the females of many Gomphinae, rudimentary, non-denticulated auricles exist.

The abdomen of the females is terminated by two unjointed dorsal appendages, belonging to the tenth segment, and therefore homologous to the superior appendages of the males. Their shape varies but little in different Odonata, and they are not known to perform any function. The anal segment lies below the appendages.

The accessory genital organs of the male and the vulvar lamina of the female will be described in connection with the reproductive organs.

THE MUSCLES.

The muscles of the Odonata are well developed, usually consisting of a number of fasciculi. Their attachments, whether of origin or insertion, may be direct or by tendon. The tendons are chitinous, and are usually of one of two kinds; in the one, the tendon is dark-colored and forms a stalked, abruptly flattened cup, to whose concave surface the muscle fibres are attached; in the other the tendon is pale in hue and conical in shape, receiving the muscle fibres at its wider end.

Where possible, the muscles described below have been identified from the general description of insectan muscles by Burmeister (32), and from Lendenfeld (4), Poletaiew (5), and Plateau (11). The chief species which has served for this account is *Aeschna constricta* Say, but comparisons have also been made with *Calopteryx* and *Libellula*. Only the most important muscles are included.

Cephalic muscles.—The muscles which move the entire head are very small. They arise from the anterior part of the mesothorax, and from the prothorax, and insert near the margins of the posterior cephalic foramen. Those dorsally placed elevate the head and draw it backwards, while the ventral ones depress it: the lateral ones draw it to either side.

Abductor labri (Burm.) arises by flat tendon from point of union of frons and vertex, passes downwards immediately behind and in contact with the posterior border of the shelf (*c*) separating the clypeus from the frons, and inserts without a tendon, into the base of the labrum close to the middle line; it elevates the labrum; the right and left abductors lie side by side.

Adductor labri (Burm.) arises in common with, but on the outer side of the abductor of the same side, but forms a distinct belly and inserts in the membranous roof of the mouth behind the labrum, and farther from the middle line than the preceding; it draws the labrum downwards and backwards.

Adductor mandibulæ (*flexor mandibulæ* Burm.) large, fan-shaped, arising from the upper part of the posterior surface of the head from near the mid-dorsal line

to more than half way down on the eye-margin, inserts by a strong, flat tendon into the inner side of the base of the mandible, which it draws towards the middle line.

Abductor mandibulæ (*extensor mandibulæ* Burm.) is considerably smaller than the preceding, on the outer side of which it lies, taking origin from the rear of the head near the margin of the eye and below the most external part of the origin of the adductor; it inserts by a round tendon into the outer part of the base of the mandible; it draws the mandible away from the middle line.

Adductor primus maxillæ (*flexor primus maxillæ* Burm.) is the largest of the maxillary muscles; it rises by a cap-like tendon from the rear of the head near the posterior foramen and inserts into the cardo and the inner margin of the stipes; with the following it draws the maxilla towards the middle line.

Adductor secundus maxillæ (*flexor secundus maxillæ*? Burm.), a strap-like muscle, arises from the rear of the head behind the adductor mandibulæ, passes within the stipes, and inserts by a small, pale tendon into the inner side of the base of the galea-lacinia.

Abductor maxillæ lies between the preceding and the abductor mandibulæ; its fibres arise from the rear of the head in a line running from the inner side of the origin of the abductor mandibulæ to the origin of the adductor secundus; they insert into the outer side of the cardo and draw the maxilla away from the middle line.

Flexor galeæ (Burm.) rises from the outer side of the stipes and inserts into the base of the galea-lacinia. Still smaller muscles are the *extensor galeæ* and the *flexor* and *extensor palpi*.

At least three pairs of muscles may be distinguished in the labium; they may be best examined by transmitted light in labia which have been cleared in clove-oil or similar reagent. All three aid in closing the labium.

Adductor labii (Burm.) arising from the lower margin of the posterior cephalic foramen, inserts into the distal end of each half of the submentum (*sm* fig. 7, pl. II).

Submentalis arises from the submedian and inserts into piece *s* (fig. 7, pl. II). Its fibres are superficial to those of the preceding.

Adductor ligulæ arises from the submentum, distal to the origin of the submentalis and inserts into the base of piece *m* (fig. 7, pl. II). Its fibres are apparently in the same plane as those of the adductor labri.

Thoracic muscles.—The muscles of the legs require no special notice.

The *wing-muscles* are large and well-developed. Their arrangement (see fig. 12, pl. II) is the same for the hind as for the front wings. Arising on or near the floor of the thorax, they pass upwards and insert on the wing-bases. The fulcrum on which each wing moves is furnished by a pleural process, shown in fig. 13, pl. II, immediately above the humeral and the second lateral sutures, respectively. It may here be designated the *fuleral process*. The muscles which elevate the wing are placed nearest the middle line of the thorax, and their insertions on the wing-base *inside* of the

fulcral process. The depressor muscles are to the outside of the elevators, while their insertions lie *without* the plane of the fulcral process. Elevation of the wing is by the operation of a lever in which the fulcrum lies between the points of application of the power and the weight, but close to the former. In depression of the wing, the fulcrum is at one end of the lever, the power being applied near to, but outside it. Lendenfeld (4) has determined the total weight and the area of the wings of some European Odonata as follows, from which the relative wing area per .1 gram. has been ascertained.

	Total weight in grammes.	Total area of wings in square centimetres.	Relative wing area in square centimetres per .1 gram. of body weight.
Aeschna cyanea ♂ ....	.92	11.45	1.2445
Libellula cancellata ♂ .....	.44	7.04	1.6
Libellula quadrimaculata ♂ ....	.29	5.54	1.91
Agrion puella .....	.026	1.10	4.23
Calopteryx virgo ♂ .....	.1	5.56	5.56

Ramon y Cajal found (Intern. Monatschr. Anat. u. Phys. v, p. 267, 1888) the nuclei of the wing muscle fibres to be central, large, and elongated; cross-sections showed radiations from the nucleus to the sarcolemma. In the fibres of the leg muscles, the nuclei are peripheral. Some additional details by the same author are contained in Zeit. Wiss. Mikros. vii, p. 335, 1890.

Muscles of the Front Wings:

Anterior depressor of the front wings (abductor alæ primæ Lendenfeld, abaisseur antérieur Poletaiew) rises on the anterior part of the mesinfraepisternum and the lower part of the mesepisternum; it inserts by a cap-tendon into the anterior axillary callus a little in front of the costa and of the fulcral process. Lendenfeld states that this muscle is "extraordinarily feeble in *Calopteryx*;" it is not so in *C. maculata*.

Accessory of the anterior depressor (pronator radii primi Lend., additionnel au abaisseur antérieur Pol.), a very small muscle, arises from the lower part of the mesepisternum near the infraepisternum, and lies upon the middle of the outer side of the anterior depressor; at about one-third its length the belly passes into a slender cap-tendon, which inserts close to and on the outer side of the insertion of the anterior depressor.

Posterior depressor of the front wings (flexor alæ primæ Lend., abaisseur postérieur Pol.) rises from the hind part of the mesinfraepisternum and the lower part of the mesepimeron, and inserts by a cap-tendon into the pleural membrane of the base of the wing, below the median vein.

First accessory of the posterior depressor (additionnel postérieur au abaisseur postérieur Pol.), a small muscle, lies on the outer and hinder side of the posterior depressor, arising from the metepisternum just behind the apodeme of the rudimentary first lateral suture and above the origin of the accessory of the anterior depressor of the hind wings; it inserts by a very slender tendon into the wing-base below the post-costa.

Second accessory of the posterior depressor (flexor radii quinti Lend., additionnel antérieur au abaisseur postérieur Pol.) is larger than the preceding, on the inner side of which it lies, and is on the hinder part of the posterior depressor; it arises from the lower part of the mesepimeron behind the origin of the posterior depressor, and inserts by a cap-tendon into the wing-base below the post-costa, almost side by side with the first accessory.

Principal elevator of the front wings (tensor alæ primæ Lend., élévateur Pol.) is a large muscle close to the middle line of the thorax and behind the anterior depressor; its origin is from the top of the mesothoracic neural canal and from the inner side of the second coxal opening, and inserts by a more powerful cap-tendon than that of any other muscle of this wing, on the extreme inner wing-base from the costa to the median vein. A small muscle extends from its tendon of insertion to the fulcral process.

Anterior accessory elevator of the front wings (pronator alæ primæ Lend., additionnel antérieur au élévateur Pol.) lies between the principal elevator on the inside, the posterior depressor on the outside, the anterior depressor in front, and the posterior accessory elevator behind; it arises from the upper, outer margin of the second coxal opening, and inserts by a cap-tendon into the wing-base below the costa; the level of its insertion is not as far forward as that of the anterior depressor. The tendon of this muscle is not cap-like in *Calopteryx*.

Posterior accessory elevator (supinator alæ primæ Lend., additionnel postérieur au élévateur Pol.) is behind the preceding; it takes origin from the upper, outer margin of the second coxal opening immediately behind the origin of the anterior accessory elevator; it inserts by a pale tendon into the wing-base below the subcosta.

Adductor radii quinti alæ primæ (Lend.) arises from the mesonotum opposite the level of the median vein, and inserts at the base of the post-costa. In front of this muscle is the insertion of the posterior accessory elevator, behind it are the insertions of the two accessories of the posterior depressor and on its outer side is the insertion of the posterior depressor.

Muscles of the Hind Wings.

Anterior depressor of the hind wings (abductor alæ secundæ Lend., abaisseur antérieur Pol.) arises from the inner, anterior part of the metinfraepisternum and the apodeme between the second and third coxæ; it inserts by a cap-tendon into the front edge of the anterior axillary callus, a little in front of the costa and of the fulcral process.

Accessory of the anterior depressor (pronator radii primi alæ secundæ Lend., additionnel au abaisseur antérieur Pol.) is a very small muscle, arising by tendon from the lower, anterior part of the metepisternum, very close to the apodeme of the rudimentary first lateral suture; its belly is short, terminating in a slender cap-tendon which inserts in the wing-base immediately external to the attachment of the anterior depressor.

Posterior depressor of the hind wings (flexor alæ secundæ Lend., abaisseur postérieur Pol.) arises from the hind part of the metinfraepisternum and the adjacent part of the metepimeron, inserts by a cap-tendon into the pleural membrane of the wing-base below the median vein.

First accessory of the posterior depressor (additionnel postérieur au abaisseur postérieur Pol.) a small muscle, lies a short distance behind the preceding, arising by tendon from the hind margin of the metasternum, and inserting by a pale tendon into the wing-base below the sub-costa.

Second accessory of the posterior depressor (flexor radii quinti alæ secundæ Lend., additionnel postérieur au abaisseur postérieur Pol.) lies on the inside of the preceding and behind the posterior depressor; it arises from the lower, anterior part of the metepimeron near the metinfraepisternum, and inserts by a cap-tendon into the wing-base below the post-costa, and immediately on the inside of the insertion of the first accessory, than which muscle it is somewhat larger.

Principal elevator of the hind wings (tensor alæ secundæ Lend., élévateur Pol.) takes its rise from the sides of the metathoracic neural canal and inserts by a very short, powerful cap-tendon into the extreme inner wing-base from costa to median vein. Like the elevator of the front wings, it has a small muscle reaching from its tendon of insertion to the fulcral process.

Anterior accessory elevator (pronator alæ secundæ Lend., additionnel antérieur au élévateur Pol.) arises from the outer upper margin of the third coxal opening, and inserts by a cap-tendon into a process on the wing-base below the costa and behind the level of the insertion of the anterior depressor.

Posterior accessory elevator (supinator alæ secundæ Lend., additionnel postérieur au élévateur Pol.) arises immediately behind the anterior accessory elevator and inserts by a pale tendon into a process on the wing-base below the subcostal.

Adductor radii quinti alæ secundæ Lend. arises on the metanotum opposite the median vein and inserts on the post-costa.

The relative positions of the muscles of the hind wings are the same as for those of the front wings, and are shown in fig. 12, pl. II.

Each wing, therefore, whether front or hind, has three elevators, five depressors and one adductor. Certain of these acting by themselves produce different effects than mere elevation or depression. Thus, the anterior depressor moves the wing horizontally forwards, the adductor horizontally backwards; moreover, the surface of the wings may be somewhat slanted from one plane to another.

The position of the first lateral suture corresponds to the line of separation between the muscles of the front and of the hind wing, the arrangement of those of the latter repeating that of the former.

Other thoracic muscles than those of the legs and wings are

Auxiliary sterno-dorsal rising from the outer side of the hind end of the metathoracic neural canal by tendon, and inserts by tendon into the tergum of the first abdominal segment; it lies close to the middle line and acts as an extensor of the abdomen, in connection with the superior tergal abdominal muscles.

Submedian ventral thoraco-abdominal arises with its fellow of the opposite side from near the mid-ventral line of the metasternum, and inserts into the middle of the anterior margin of the first abdominal sternum. It is a flexor of the abdomen in connection with the sternal abdominal muscles, with which it is perhaps homologous.

Lateral thoraco-abdominal, with its fellow of the other side, arises by a common tendon from the roof of the metathoracic neural canal; the bellies separate, diverge, run backwards and insert by a pale tendon into the side of the anterior margin of the first abdominal sternum; together they act as an abdominal flexor, separately to pull the abdomen to that side.

The **abdominal** muscles are longitudinal and transverse. The longitudinal muscles are tergal and sternal. Of the longitudinal tergal there are two sets: the *superior longitudinal tergal abdominal* muscles pass from the anterior dorsal part of the tergum of one segment to the same posterior part of the next in front; the *lateral longitudinal tergal abdominal* muscles pass from the inferior lateral margin of the tergum of one segment and the adjacent pleural membrane to a region somewhat higher up on the tergum of the preceding segment. The *longitudinal sternal abdominal* muscles are quite small, and pass from the anterior part of the sternum of one segment to the posterior part of the preceding sternum. The contraction of the superior tergals of both sides is to extend the abdomen in a straight line, of the sternals of both sides to flex the abdomen ventrally upon itself, while a contraction of the muscles of one side of the abdomen only will bend it towards that side. *Transverse* muscles occur in the second abdominal segment of the males from tergum to sternum; and in the spiracle-bearing segments as *vertical expiratory* muscles (Plateau 11) connecting the terga with the second lateral sternal process, and which aid in the contraction of the abdomen in the act of expiration.

THE ALIMENTARY CANAL.

The alimentary canal is a nearly straight tube running from the mouth on the lower surface of the head to the anus in the rudimentary eleventh, or anal segment. It consists of three parts: the *fore*-, the *mid*-, and the *hind-gut*. The first and last are formed from the ectoderm of the embryo, like the integument, and have a chitinous lining; the mid-gut is of endodermal origin and the chitinous lining is absent.

The fore-gut (œsophagus and crop) extends from the mouth to the second abdominal segment. Its walls are very distensible, particularly at its hinder end. Its only appendages are a pair of *salivary glands*, which were discovered and described by Poletaiew (9). The glands are compound, and lie in the prothorax. Each acinus is tolerably long and narrow; their number is greater in the Anisoptera (above 150) than in the Zygoptera (50), and in the former group they are more closely bound together by a tracheal network. The acini of each gland eventually form a single duct, which dilates into a reservoir, after which it unites with its fellow of the other side. The common opening is on the underside of the hypopharynx, where

it joins the labium. The development of the salivary glands begins in a late nymphal stage.

The mid-gut (chylific ventricle) extends from the second to the hind part of the seventh abdominal segment. Its walls are thicker than those of the fore-gut, and are transversely ringed. The opening between the fore- and the mid-gut is valvular, so formed by the hind end of the fore-gut extending a short distance into an invagination of the front end of the mid-gut. There are no appendages (cæcæ) to the mid-gut. Faussek (7) has described the histological structure of the mid-gut. The epithelium consists of high, very narrow, cylindrical cells, and does not form folds; between these cells are many fairly large glands (crypts) whose cell-nuclei, in contradistinction to those of the epithelium proper, show mitosis. External to the epithelium is a structureless membrana propria, then in succession outwards, a circular muscle, a connective tissue and a longitudinal muscle layer. This description applies to the mid-gut of Aeschnid, Libellulid and Agrionid larvæ, and to the imago of *Diplax striolata*.

Griffiths (Physiol. of Invert. p. 94, 1892) finds the fluids within the mid-gut (secretions of the crypts) to be always slightly alkaline; an infusion of about twenty such mid-guts readily converted starch into glucose and digested fibrin.

The hind-gut (rectum) extends from the seventh abdominal segment to the anus. No valve exists between mid- and hind-gut, but the anterior extremity of the latter is marked by the attachment of the Malpighian tubules, which may be regarded as appendages of the hind-gut. The walls of this part are also thicker than those of the fore-gut. A constriction divides the hind-gut into two parts, the anterior part being of larger calibre, and having on its inner surface longitudinal ridges, representing the branchial ridges of the nymph. These ridges fade away in the posterior part of the hind-gut.

The Odonata are rapacious and carnivorous, both as nymphs and as imagos, the former feeding on young fish, tadpoles, aquatic insects and probably many other water-dwelling animals. The food of the imagos consists mainly of insects of all orders, including their own, but especially of soft-bodied Diptera and Hemiptera. Dr. Abbott found dragonflies feeding on the decomposing remains of a calf in New Jersey, in October ("Upland and Meadow," p. 316). The cannibalistic habits of the Odonata are shown by the following facts:

it has frequently been remarked by those who have reared them in captivity, that the nymphs devour nymphs of their own and of other species. Stefanelli observed the nymphs of the European *Aeschna cyanea* to come out of the water at night and attack and devour the newly-transformed imagos of the same species. Miss Wadsworth has seen an imago of *Dromogomphus spinosus* devouring an imago of *Calopteryx maculata*, and Kuthy records *Brachytron pratense* preying on *Somatochlora flavomaculata*.

The **excretory organs** are appendages of the alimentary canal. They are known as the *Malpighian tubules*, and, as already mentioned, are attached to the point of junction of mid- and hind-gut. Their number is from 50 to 70. The fullest account of them is by Griffiths (8) for the European *Platetrum depressum*. In this species they are 60 to 70 in number and unbranched; each consists, from without inwards, of "a connective tissue layer, a delicate tracheal tube, a basement membrane, and lastly an epithelial layer of comparatively large nucleated cells." The cavity of the tubule is very irregular. The secretion of the tubules yielded uric acid, and no other ingredient was detected.

THE CIRCULATORY APPARATUS.

The circulatory apparatus, so far as it has been recognized in the Odonata, consists of a dorsal vessel of extreme tenuity, lying in the abdomen above the alimentary canal and extending into the thorax. Blanchard states that its openings are hardly visible and not marked by constrictions; he counted seven pairs in *Gomphus* (Ann. Sci. Nat. 1848, Zool. ix, p. 389). In the hind part of the dorsal vessel of some Odonata are unstriated muscle fibres which are described by Vosseler.* A ventral abdominal pulsating sinus is also recognized by Graber.

In close connection with the dorsal vessel and with the abdominal tracheæ, are masses of yellow *fat*, to which Graber assigned the functions of absorption and the conveyance of nutrition to the various organs ("Die Insekten," vol. I).

THE RESPIRATORY APPARATUS.

The respiratory apparatus consists of three pairs of main longitudinal tracheæ with their branches. The three pairs are found as such only in the abdomen, where, from their position, they are termed ventral, visceral and dorsal.

* Untersuchungen über glatte und unvollkommen quergestreifte Muskeln der Arthropoden. Tübingen, 1891. Pp. 94-95.

The *ventral* pair lie, one just beyond either lateral margin of the abdominal sterna. Each ventral trunk receives a branch from each of the eight abdominal spiracles of its own side of the body. The spiracles, as already mentioned in describing the abdominal skeleton, lie in the anterior part of the pleural membrane which connects the terga and sterna of the first eight abdominal segments. Each spiracle is elongated in the direction of the long axis of the body, and in the Aeschnidæ and Libellulidæ, at least, is guarded by a chitinous flap, a prolongation of one side of the margin of the opening; the free edge of this flap and the margin opposed to it are bristly. In the Agrionidæ this flap is apparently absent. Each ventral trunk supplies tracheal branches to the ventral nerve cord, the sternal abdominal muscles and the reproductive organs. In the posterior part of the thorax, each ventral trunk, which is there quite small, becomes connected with a branch of the dorsal trunk; in its course through the abdomen, a number of cross-tracheæ connect it with the dorsal trunk; at about the level of the seventh pair of abdominal ganglia, it becomes connected with the visceral and the dorsal trunk of the same side by means of a large cross branch (*Libellula pulchella*).

Each *visceral* trunk is attached to its respective side of the alimentary canal from near the hind end of the mid-gut to the base of the abdomen (*L. pulchella*), where it appears to be connected with branches of the dorsal trunks. Each visceral trunk supplies numerous branches to the mid-gut; as just mentioned it unites posteriorly with the ventral trunk of the same side and from the point of union, small tracheæ proceed to the Malpighian tubules and hind-gut.

The *dorsal* trunks are the largest of the three pairs; in the abdomen they lie above the alimentary canal, one on either side of the median line, with the dorsal (blood) vessel between them. In the thorax, however, they become ventral (*L. pulchella*) and pass into the head, supplying by their numerous branches, the organs in both head and thorax and having two pairs of external orifices—the thoracic spiracles; beyond the middle of the abdomen each trunk bifurcates (*L. pulchella*), but the two branches continue backwards side by side to the cross-trunk by which communication is had with the united visceral and ventral trunks, after which they again separate and supply the region of the hind-gut; the tergal abdominal muscles are mainly supplied by the dorsal trunks. In the second abdominal segment each dorsal trunk has connected with it, by means of tracheal stalks, two or more air-sacs. Ventral and dorsal trunk of each side are connected by cross-tracheæ.

The *thoracic spiracles* are considerably larger than the abdominal. Of the two pairs, the more anterior are the *mesostigmata*, which are situated, one in the fore part of each mesepisternum. Each mesostigma (see Pl. II, fig. 13) is a narrow, transversely elongated opening and from its position is often partly concealed by the hind lobe of the prothorax. Within its lips is a chitinous, comb-like piece, first described by Landois (Zeit. Wiss. Zool. xvii, p. 167, 1866) as a sound-producing organ. The number of teeth of the comb varies for different species and their length is not the same in different parts of the comb. Between the larger teeth is a folded membrane consisting of a single layer of rather larger cells. The second pair of thoracic spiracles are the *metastigmata*. Each metastigma lies on the side of the thorax in the lower part of the metepisternum; it is shorter, but wider than the mesostigma, is without a chitinous comb, but is guarded by a chitinous flap whose surface is spinous; probably the comb of the mesostigma is merely a modification of such a flap.

There are thus ten pairs of spiracles altogether, all functional.

Both Landois *l. c.* and Krancher (Zeit. Wiss. Zool. xxxv, pp. 551-3) regard the thoracic spiracles as belonging to pro- and mesothorax respectively; the latter describes the metastigma and the abdominal spiracles in detail. There is apparently no reason for thinking that the mesostigmatic comb does produce sound.

The preceding account of the distribution of the tracheæ is based on personal dissection of *Libellula pulchella*. The writer is not aware that information exists as to the variations which may occur between the imagos of different groups. The account given above should be compared with the summary of the results of various students who have treated of the tracheæ of the nymphs (see *post*). The writer is not acquainted with the contents of Dr. Palmen's "Morphologie des Tracheen-Systems," a work which he has not seen.

The respiratory movements (Barlow 10, Plateau 11) consist in an alternate expansion (inspiration) and contraction (expiration) of the abdomen. The expansion or contraction is simultaneous in all the segments, the length of the abdomen is not altered. The rate of movement* varies greatly at different times owing to unknown causes, but is always quickened by exercise, increased temperature, galvanism and mechanical irritation; the last three agents quicken the movements in the decapitated insect as well. To adopt the con-

* In an entire *Libellula cyanea* held in the hand, the inspirations were 73 per minute; similarly in a *Plathemis trimaculata*, 105-118 per minute. Another individual of this latter species immediately after alighting upon a fence-rail, inspired 70 times per minute.

venient form used by Plateau, the abdominal movements may be tabulated as follows:

INSPIRATION.

Slower, with decreasing activity; an
inspiratory pause.
Sterna lowered.
Ventral parts of terga move outwards.
Dorsal carina lowered.
Abdomen descends.

EXPIRATION.

Rapid and short.
Sterna elevated.
Ventral parts of terga move inwards.
Dorsal carina elevated.
Abdomen slightly raised.

The expiratory movements are accomplished by the abdominal muscles, especially the vertical expiratory. The inspirations are effected by the relaxation of the muscles.

Each pair of abdominal ganglia acts as a respiratory centre for its own segment, independently of the others. Decapitation does not stop the respiratory movements, but diminishes their number and amplitude; in one instance they continued for forty-three hours after removal of the head.

THE NERVOUS SYSTEM.

The central nervous system consists of twelve distinct ganglionic masses, of which two are in the head, the supra- and the subœsophageal; three are thoracic and seven are abdominal.

The *supra-œsophageal* ganglionic mass consists of the medianly situated *brain*, or cerebrum, connected with which on either side is a very large optic ganglion. The brain lies between the upper half of the posterior foramen and the partition formed by the chitinous rods (*b*) as described for the endoskeleton of the head. Its surface is not lobed, but as it supplies nerves to the eyes, ocelli, antennæ, frons and labrum, it is to be regarded as compound in its origin, like that of other insects. Blanchard (12) shows the cerebrum of *Gomphus forcipatus* (= *vulgotissimus*) to give off one pair of optic nerves, one pair of antennal, one labral pair, one pair uniting in a frontal ganglion and one pair of small posterior tracheal.

The *optic* ganglia, large in all the Odonata, are especially so in the Aeschninæ and Libellulidæ, in correlation with the proportionately large area of the eyes in these groups. Each ganglion is connected with the brain by a distinct stalk—the optic nerve. The histological structure of the optic ganglia has been studied by Berger (14) and Viallanes (16); their results agree, and the latter summarises them as follows:

"From each elementary eye [of the compound eye] proceeds a nerve fibre (post-retinal fibre). All the post-retinal fibres are directed inwards, and traverse in their passage a sort of interposed nervous screen, which I will describe under the name of ganglionic plate. After having traversed this latter, the fibres continuing inwards, interlace completely, and so form the external chiasm. The fibres of the external chiasm then sink into a mass of granular substance known under the name of external medullary mass. They reappear to interlace again and form a second chiasm, the internal chiasm, and to acquire a second mass of granular substance, the internal medullary mass. The nerve fibres, after having traversed this mass reappear to form the optic nerve and proceed directly to the brain. We will add that to each of the masses of granular substance are annexed masses of ganglionic cells, from which they receive prolongations."

The circumoesophageal nerve-ring closely surrounds the alimentary canal, so that the interval between supra- and suboesophageal ganglia is a short one.

The *suboesophageal* pair of ganglia lie immediately below and behind the oesophagus as it turns downwards to the mouth. It supplies a pair of nerves each to the mandibles, maxillæ and labium.

The three *thoracic ganglia* are pro-, meso- and metathoracic respectively. The prothoracic pair innervates the first pair of legs, the mesothoracic the second legs and the front wings, the metathoracic the third legs and the hind wings.

The relative size of these three pairs varies. Thus in *Epiæschna heros* the prothoracic ganglia were found to be the smallest of the three, while in *Libellula auripennis* they were fully as large as the other two. In *Calopteryx maculata*, *Aeschna constricta* and *Epiæschna heros* the meso- and metathoracic ganglia are distinct from each other, while in *Libellula auripennis*, *L. pulchella* and in *Gomphus vulgatissimus* (according to Blanchard's figure), they are united. This union suggests a correlation with the obliteration of a considerable portion of the meso-metathoracic, or first lateral, suture, but as the same obliteration is also found in the Aeschninæ, the union of the ganglia in the Gomphinæ and Libellulinæ has probably followed the appearance of the suture—if the correlation really exist throughout these two groups.

The distribution of the *abdominal ganglia* is, as far as known, the same for all groups. The first pair lies in segment 1, the second in 3, the third in 4, the fourth in 5, the fifth in 6, the sixth in 7, the seventh in 8. The abdominal ganglia are smaller than the thoracic, and are proportionately larger in *Calopteryx* than in *Aeschna*. Each

pair supplies the muscles of its own segment; segment 2 is supplied by branches from the first pair of ganglia, segments 9 and 10 and the terminal appendages by the seventh pair. The experiments of Barlow (10) Plateau (11) and others have shown that each pair of abdominal ganglia is a respiratory centre for its own segment. The high degree of independence of the rest of the nervous system possessed by the different parts is shown by the experiments of Stephens (Ent. Mag. I, p. 518, 1833), who induced an *Aeschna* to devour its own terminal four abdominal segments, and which then "fled away as briskly as ever;" by similar experiments of the writer on *Pachydiplax longipennis*; and by the continuance of respiration after decapitation, or in portions of the abdomen consisting of three or four segments which have been removed from the rest of the body, as noted by Barlow.

The termination of the motor nerves in the nymph of *Libellula* has been investigated by Gabbi, who finds that the sheath of the nerve enters into close relations with the primitive muscle-bundle and is continued into the sarcolemma which forms the so-called elevation of Doyère. The axis cylinder penetrates the apex of the elevation of Doyère and divides into two branches at the base of the cone. The motor termination is situated below the sarcolemma (Bull. Soc. Ent. Ital. XVIII, pp. 310-333, 1886).

Special Sense Organs.—The external features of the compound eyes have been already referred to (p. 155), where the difference in size between the facets of the upper and lower surfaces in the eyes of the Libellulidæ and Aeschninæ was mentioned. Exner finds that the separate facet-members of the upper surface are absolutely, but not relatively longer, and possess no black pigment; the reverse is the case in those of the lower parts, and the transition between the two kinds in these respects is quite abrupt.* When the eyes of the living insect are examined, a number of black spots are seen, which change their location as the eye is looked at from various points of view; these are the "pseudopupillæ." Exner believes that the upper part of the eye is for "the perception of movements, the lower for the perception of form of resting objects," a conclusion for which he finds support in the fact that the pseudopupillæ of the upper surface move more rapidly, when the insect is turned in the hand, than do those of the lower surface (Die Physiologie der facettirten Augen von Krebsen und Insecten. Leipzig u. Wien, 1891). On the other hand, Plateau considers that the Odonata do not perceive form, but merely motion (Bull. Ac. Belg. (3), XVI, pp. 417-425, 1888).

Lespes describes (Ann. Sci. Nat. (4), IX, p. 240, 1858) certain structures on the antennæ which he regarded as auditory; in *Agrion*, on the third antennal joint, he found an opening closed by a white membrane, and on the fifth four tympanules placed in line, one above the other; in *Libellula* (*Diplax*) *vulgata* was nothing

* Additional details on the histological structure of the eyes are given by Lowne, Trans. Linn. Soc. (2) II, pp. 389-420, and Hickson, Quart. Journ. Micr. Sci. (n. s.) XXV, pp. 222-223, etc.

similar to the first opening described for *Agrion*, but the third joint bore four tympanules; the profile of the tympanules was convex, and otoliths within very evident.

Packard has described as organs of taste the setæ and "taste-cups" situated on the inner surface of the labrum (Psyche, V, p. 223, 1889).

The sympathetic nerves of *Libellula depressa* have been described and figured by Brandt (13). From either side of the brain, near and in front of the origin of the antennal nerve, a nerve runs forwards and unites with its fellow of the opposite side in the frontal ganglion, from which a pair of small nerves is given off to the labrum; posteriorly the frontal ganglion gives off an unpaired nerve to the œsophagus. Lying on the dorsal surface of the œsophagus, immediately behind the brain are two pairs of small ganglia, of which the anterior pair is on the middle line and in contact, while the posterior pair is separated, each ganglion lying on the lateral margin so to speak of the œsophagus; anterior and posterior pairs are connected; nerves are supplied to the œsophageal walls. Apparently it is the posterior pair which corresponds to the pair of tracheal ganglia of Blanchard.

We know but little as to the intelligence of the Odonata. Fennel records (Mag. Nat. Hist. VI, pp. 271-272, 1833) an observation of interest on this topic. A male and a female of a species of *Aeschna* were flying and sporting over a pond, when another male appeared and chased the female. The first male turned upon the newcomer, and a struggle ensued between the two males until one fell into the water; the other alighted upon him as he floated on the water's surface, remained there for a short time and then joined the female, who had continued to fly around the pond without manifesting any interest in the combat. An examination showed that the conquered male had been deprived of his wings by the victor, and so was unable to rise. A natural interest as to whether the victor was the original possessor or the newcomer, is not gratified by the narrative.

THE REPRODUCTIVE ORGANS.

The Odonata are in all cases unisexual. The **male** reproductive organs—*testes* are paired, one lying on either side of the abdomen above the alimentary canal. Each testis is an elongated, cylindrical organ, held in place by tracheæ; when fully developed, its anterior extremity lies in the fourth segment. At its hind end each narrows somewhat to form the vas deferens, which passes below the hind-gut in the seventh or eighth segment and only unites with its fellow of the opposite side at the common opening on the ventral surface of 9. The two vasa deferentia are without permanent dilatations or seminal vesicles. The opening of the common duct, as already mentioned, is guarded by a chitinous flap on either side.

The *spermatozoa* of the Agrionidæ and the Aeschnidæ are very slender, very agile and of hair-like form, while those of the Libellulidæ are thicker and immobile (Siebold 17). Several stages in the development of those of *Agrion puella* and *Calopteryx virgo* are described and figured by Butschli (Zeit. Wiss. Zool. XXI, pp. 528, 529, pl. xl, 1871).

The *external genital organs* of the male are separated from the orifice of the duct of the testes and lie in a pocket on the ventral side of the second abdominal segment, entirely outside the body cavity and having no communication with it. They consist of a *penis* and its *vesicle*, lying in the median line, and on either side of these one (Libellulidæ) or two (Aeschnidæ, Agrionidæ) pairs of processes—*genital hamules* (see Pl. II, figs. 3–6). The vesicle of the penis is a sack with chitinous walls, lying at the hind end of the pocket and firmly attached at its basal end to the anterior portion of the sternum of 3. Its distal extremity may (Anisoptera) or may not (Zygoptera) be attached to the penis. In the former case the penis is a three-jointed, chitinous tube, bent ventrally on itself and then directed backwards, with its cavity (lumen) continuous with that of the vesicle; a longitudinal opening to the exterior is present on the convex side of the second joint, and the apical, or third joint terminates variously in different species. In the latter case the penis is unjointed, and is attached to the floor of the pocket (*i. e.* to the sternum of 2). In either case the penis is situated immediately in front of the vesicle. The hamules are variously shaped; the anterior pair is the larger in the Agrionidæ and the Aeschninæ, the smaller in the Gomphinæ; the single pair present in the Libellulidæ corresponds to the posterior pair (Hagen, 39, pp. 273–74). In front of the anterior pair, the anterior sternal border of 2 forms a variously-shaped, downwardly-projecting piece—the *anterior lamina*—which forms the front boundary of this genital pocket. Between the hamules, and immediately in front of the penis, there is in the Aeschnidæ, and to a less extent in the Agrionidæ, a median, hood-like, chitinous piece, under whose arch the penis is folded when not in use. This is the *sheath of the penis*.* In the Libellulidæ this is

* It is here to be remarked that de Selys and Hagen (40, 43, and in their *Revue des Odonates d'Europe*) have applied the term "sheath of the penis" (*gaine du pénis*), not as by Rambur (33) and as above, but to the vesicle of the penis, while the real sheath of the penis is called the *cuillere*. Rambur's description is very clear, and his terms are followed in the text. Hagen uses the term "vesicle of the penis" in (36).

absent, but a posterior, backwardly and downwardly-directed process (*genital lobe*) arises from either side of 2, and between those of the right and left sides, the vesicle of the penis lies. The hamules are apparently for clasping the edges of the vulvar lamina during copulation. The sheath of the penis and the genital lobes are protective organs.

The separation of the orifice of the duct of the testes and the intromittent organ in the Odonata is not a unique occurrence in the animal kingdom. In male spiders the common duct of the testes opens on the base of the abdomen, while a pedipalp is modified to form the copulatory organ. So, also, among the Cephalopods, one of the arms of the male is modified (hectocotylized arm) for the purpose of introducing the spermatophores within the mantle of the female.

The reproductive organs of the **female**, the *ovaries*, are also paired and occupy the same relative position as the testes; when functionally active, they extend forwards even as far as into the hind part of the thorax. The ovarian tubes are very numerous and open into an oviduct which unites with its fellow of the other side, in the eighth segment, to form the vagina. The vagina is provided with a dorsal pouch—*bursa copulatrix*—and one or two *receptacula seminis*. In *Calopteryx*, the receptaculum consists of two small lobes which unite in a common canal; in *Agrion* there is a single lobe; in the Anisoptera there are two receptacula, each with a distinct canal (Siebold 17). The external orifice of the vagina (vulva) is at the ventral apex of 8. It may be simply an uncovered opening, or the posterior extremity of the sternum of 8 may be prolonged as the *vulvar lamina* to assist in oviposition.

In the Agrionidæ, the Aeschninæ, the Cordulegastrinæ, and some Gomphinæ, the vulvar lamina is prolonged into two trough-like plates, pointed at their distal extremities, with their concave faces opposite each other so as to form a tube-ovipositor. Each plate consists of two curved styles united side by side; on the outside near the apex are some transverse ridges forming a file-like surface (Agrionidæ, Aeschninæ). In the Agrionidæ, Aeschninæ, and certain Gomphinæ (*Petalura*), there lies on either side of this ovipositor a chitinous piece—*genital valve*, derived from the sternum of 9. Articulated to the apex of each genital valve is a slender, unjointed process (*valvular process*) which terminates, in the Aeschninæ and the Gomphinæ of the legion *Petalura*, with a small bundle of hairs; in the Agrionidæ these hairs are absent. The function of the genital valves is probably to assist in the placing of the eggs within incisions (made by the pointed and roughened ends of the ovipositor) in the

tissues of water plants, and also to steady the abdomen during oviposition. In the remaining Gomphinæ and in the Libellulidæ, the vulvar lamina, although often large and variously shaped, does not serve for the insertion of eggs within plants, and there are no genital valves.

The *ova* (unfertilized) are elongated, and as they lie with their long axes parallel to the long axis of the ovarian tubes, their two extremities may be definitely distinguished as anterior and posterior poles. The anterior pole is that which is towards the head of the mother; it corresponds to the head end of the embryo in late, though not in early, embryonic life. The other pole is the posterior, is directed towards the tail end of the mother and corresponds to the tail end of late embryonic life. The micropyle is situated at the anterior pole.

Secondary sexual differences are of size, of structure and of color. In some groups the males, in others the females are larger, as may be seen from the dimensions given for the species in Part II. Structural differences are found in differences of venation of the post-costal space in some Calopteryginæ (*Heterina*); in the shape of the prothorax and of the tenth abdominal segment in many Agrioninæ; in the shape of the occiput, the relative development of the femoral spines, and the possession of spines on the vertex by the female, in many Gomphinæ; in the replacement of the tibial spines by knobs in the males, but not in the females of *Cordulegaster*; in the possession of auricles and an excavated anal border of the hind wings by the males of Cordulinæ and many Aeschnidæ. When the colors of male and female are different, those of the male are usually brighter. The pattern of coloring both of abdomen and of wings may be quite different in the two sexes; in such cases, that of the teneral male is more like that of the adult female than is that of the adult male. From various considerations Walsh concluded that in many [*e. g.* the Calopterygine *Lais* and *Heterina* and some *Gomphus*] though by no means in all Odonatous groups there is a great overplus of males (Proc. Ent. Soc. Phila. ii, p. 223).

Dimorphic females exist in the Libelluline genus *Neurothemis*, where the heteromorphous female has a more open venation than the male and the isomorphous female (Brauer), and in the Agrionine genera *Ceratura*, *Anomalagrion*, *Ischnura* (see Part II) and *Agriocnemis*, where the coloring of the heteromorphous female is quite different from that of the male and normal female (Selys).

Hagen has recorded instances of the copulation of different species, but nothing is known of their progeny (Ent. Weekly Intel. 1857, pp. 62, 63. Stet. Ent. Zeit. xix, p. 44, 414-15, 1858).

OVIPOSITION.

Owing to the separation of the intromittent organ from the external opening of the vas deferens in the male, an essential prelude to the act of copulation is the filling of the vesicle of the penis with sperm. This is accomplished by the curving of the abdomen ventrally upon itself so that the ventral surfaces of the ninth and second segments come in contact. While no precise details have been recorded, it seems probable that in the *Zygoptera* the sperm passes directly from the vas deferens through a fissure on the free end of the vesicle to its interior, and the penis is filled by applying it to the vesicle. In the *Anisoptera* the sperm passes through the penis into the vesicle. This preliminary stage ended,* the male flies after a female, seizes her by his feet, and then clasps her prothorax with his abdominal appendages. She then curves the apex of her abdomen ventrally forwards and upwards, so that the vulva shall come in contact with his accessory genital organs, and the sperm is introduced into the vulva by the penis. During copulation, therefore, the male is above and in front of the female; the heads of both are turned in the same direction. While in most of the groups the act of copulation lasts but for a very short time and takes place while flying, it would appear that among the *Agrioninæ* a considerable period elapses between the clasping of the female's prothorax and the curving of her abdomen to meet that of the male, and that the impregnation is effected when at rest. The spermatozoa upon being received into the vagina pass into the receptacula seminis and the bursa copulatrix, and the eggs are fertilized as they pass the openings of these pouches on their way down the vagina.

Oviposition, as a general rule, immediately follows copulation. In the *Agrionidæ*,† the *Aeschninæ*, and probably in the *Petaluroid Gomphinæ* and the *Cordulegasterinæ*, the eggs are laid within the tissues of plants below the water's surface in conformity with the

* Todd records the male of *Lestes* as charging the seminal vesicle *after* the female had been seized (Amer. Nat. xix, pp. 306-7).

† Apparently the only observation which conflicts with this statement is that of Walsh (Proc. Ent. Soc. Phila. ii, p. 322), who "observed that *Heterina* ♀ flirts her eggs into the open river, without attaching them to aquatic plants." This assertion should be tested by further observations.

structure of the vulvar lamina as an ovipositor; this may be termed *endophytic* oviposition. In the other subfamilies no ovipositor exists, and the eggs are merely dropped into water or attached by a gummy substance to the surfaces of submerged bodies; such oviposition may be styled *exophytic*. In either of these cases the male may or may not retain his hold of the female's prothorax by his appendages during oviposition.

1. *Endophytic oviposition*.—A favorable opportunity enabled the writer to see, in *Argia violacea*, an Agrionine, the sharply pointed and roughened ends of the halves of the vulvar lamina cut into plant tissue and push the eggs into the incisions. The valves assist in the deposition and probably also steady the abdomen. The first eggs in this case were laid just below the water's surface, the female gradually descending and inserting the eggs farther and farther downwards. The laying of the eggs in plants below the surface, necessitates the descent of the female into the water, so that she may be completely submerged, as the writer has witnessed in *Enallagma exsulans*, and as has been observed in different species of Agrioninæ and Aeschninæ by many others. When the male retains his grasp of the female's prothorax during oviposition, and the female continues to descend, he usually loosens his hold and separates from the female to avoid being dragged into the water. Von Siebold saw the male of *Lestes sponsa* also descend below the surface with the female, and the writer has witnessed the same phenomenon in three different pairs of *Enallagma exsulans*. When immersed, both male and female are encased by an envelope of air. After eggs have been deposited in a plant, by holding the latter between one's eyes and the light, the eggs can usually be seen lying between the veins of the leaf-blade. While the male and female of endophytic groups remain attached during oviposition to a greater extent than in the exophytic groups, yet *Anax junius* and *Ischnura verticalis* have been seen by the writer at one time to lay the eggs without the attachment, or even presence of a male, and at other times to lay them with the male attached.

2. *Exophytic oviposition*.—The female repeatedly dips the end of her abdomen into the water at a rate, in *Plathemis trimaculata*, of 120–150 dips per minute. At other times she strikes the water with her abdomen with such force as to fasten the eggs upon the vertical surface of rock (Buckhout). The eggs of this group are found to be covered with a transparent substance which causes them to adhere to adjacent objects. The dipping of the female's abdomen

enables the water to wash the eggs from her body. While the eggs are usually distributed in small numbers, Gerard found bunches of 30-40 egg-masses, each twelve to fifteen inches long and one-eighth of an inch in diameter, with about 500 eggs to the inch, and which subsequently yielded Libelluline larvæ (Am. Ent. iii, pp. 174-75). While the male usually releases his hold of the female immediately after copulation, *Diplax* frequently oviposits in pairs. Even when the male separates, he frequently follows the female while she is discharging the eggs.

Most individuals probably pair more than once. A second pairing may take place while a female is in the very act of oviposition, as the writer has observed in *Plathemis trimaculata* and *Libellula pulchella*; in both of these cases, after the interruption, the female resumed the discharge of the eggs.

2. DEVELOPMENT OF THE ODONATA.

EMBRYONIC (oval) DEVELOPMENT.

The eggs of the Odonata are smooth, pale yellow, elongated in the endophytic, elliptical and wider in the exophytic forms. The period of oval development varies from six days in *Libellula pulchella* and *Ischnura verticalis*, to three weeks in *Calopteryx virgo* (Brandt). The number of eggs laid by one female is very variable; 300 was the highest found by Brandt in *C. virgo*.

Our knowledge of the embryonic development of the Odonata is based chiefly on the researches of Brandt (18) on *Calopteryx virgo*. What is here presented is mainly an abstract of his paper.

The anterior pole of the freshly-laid egg is distinctly more pointed than the posterior. An examination of the outline of the egg shows one of its long sides to be almost straight, while its opposite side is distinctly convex; the straight side corresponds to the *ventral* surface of late, but not early, embryonic life, and the convex side to the dorsal surface of late embryonic life, and will be so designated in the following account. The length of the egg is 1 mm., its greatest breadth .2 mm. Two membranes enclose the egg, an outer (chorion) and an inner (vitelline membrane). The chorion is structureless and at first colorless; it is thickened at the anterior pole, and here also a small gelatinous mass adheres. The micropyle passes excentrically through the summit of this thickening of the chorion. Moreover, a delicate, folded, funnel-like membrane is

placed just beyond the gelatinous mass. Both membrane and mass increase the facility of entrance of the spermatozoa into the egg. Within the very thin vitelline membrane are mostly yolk spheres and fat drops with, of course, the egg-nucleus.

The blastoderm does not apparently arise as a continuous layer, but in isolated patches, which afterwards unite and form a single layer of cells over the entire surface of the egg, but within the egg membranes. Six to twelve hours from the time of oviposition were required for its complete formation. The blastoderm then thickens slightly at both poles and also on the ventral surface near the posterior pole. This latter thickening (the *ventral plate*—*Bauchplatte*—*bp*, fig. 33A) is shield-shaped and consists of two or more layers of

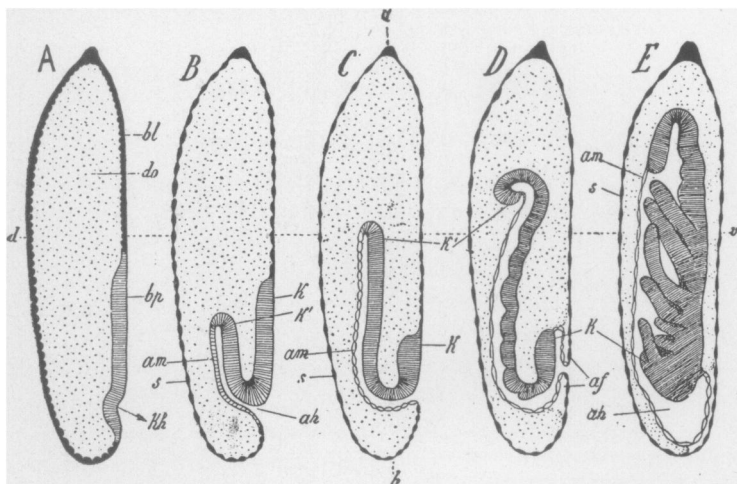


Fig. 33.

Five diagrammatic median longitudinal sections of the egg of *Calopteryx* (after Korschelt and Heider, based on Brandt).

A—E, successive stages in development. The egg-membranes are omitted.

a, anterior pole of egg.

af, amnion fold.

ah, amnion cavity.

am, amnion.

b, posterior pole of egg.

bl, blastoderm.

bp, ventral plate.

d, dorsal side of egg.

do, yolk.

k, head end of the germinal band.

kt, tail end of the germinal band.

kh, beginning of the invagination.

s, serosa.

v, ventral side of egg.

cells, but fades, without distinct boundaries, into the rest of the blastoderm. An invagination now takes place in the ventral plate in the form of a tube-like insinking into the central part of the egg

(fig. 33B). The cavity of this tube is the *amnion cavity*; its inner blind end is directed towards the anterior pole of the egg, which it approaches more and more as the tube increases in length. The blind end is what will hereafter be the tail end of the embryo, and at this stage of development, is much nearer the anterior than the posterior pole. The walls of this tube are, from their mode of origin, continuous with the uninvginated parts of the ventral plate; as the tube increases in length, that part of its walls nearest the dorsal surface of the egg steadily diminishes in thickness until it forms a mere

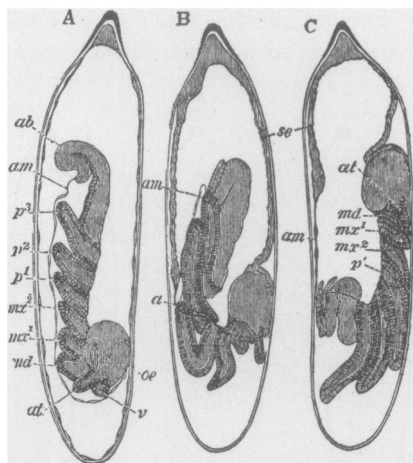


Fig. 34.

Three later stages of the embryonic development of *Calopteryx*, showing the turning of the embryo within the shell (after Korschelt and Heider, based on Brandt).

The egg-membranes are shown here.

a, opening of the amnion cavity through which the embryo passes.
ab, hind part of the abdomen.
am, amnion.
at, antenna.
md, mandible.

mx1, first maxilla.
mx2, second maxilla (half of labium).
oe, beginning of oesophagus.
p1, *p2*, *p3*, first, second and third leg.
se, serosa.
v, front head.

membrane—the *amnion*; that part of the wall nearest the ventral surface of the egg is not thinned, and gives rise eventually to the entire ventral surface of the embryo and the paired appendages, including those of the head (fig. 33C).

Meanwhile, the uninvginated portions of the ventral plate are gradually reduced to a sharply circumscribed area in front of the mouth of the amnion cavity, and become divided into two bilaterally

symmetrical halves—the *lateral lobes* (*Seitenlappen*), which eventually take part in the formation of the head. The thick part of the wall of the invaginated tube, together with the lateral lobes, forms the *germinal-band* (*Keimstreif*).

While the above-described changes have been taking place in the germinal band, the cells of the rest of the blastoderm, except at the anterior pole, have become flattened and surrounded by an intercellular substance. The most external layer of cells of the lateral lobes undergoes the same change, unites with the similar cells around the mouth of the invagination, and so closes the open end of the amnion cavity. The egg is thus enveloped by a membrane—the *serosa*—which is entirely free and unconnected with the amnion,* or the germinal band. Meanwhile the yolk, which lies almost everywhere between the serosa and the embryo, has been divided into spheres.

The deep (hind) end of the germinal band now curves so that the hind part of the abdomen becomes folded ventrally upon itself. Three pairs of swellings appear on the amniotic side of the germinal band, the beginnings of the three pairs of legs. In front of these (in this stage of development, nearer the posterior pole of the egg) three similar pairs of swellings soon appear, which will be the two pairs of maxillæ and the mandibles (fig. 33D). The length of these swellings decreases from behind forwards. As soon as these swellings are clearly recognizable, two distinct layers can be seen to be forming in each—an outer, skin layer and an inner, nerve-muscle layer; each layer of each swelling is continuous with the similar layer of the swelling in front and behind. As they increase in length, the swellings are directed towards the hind end of the embryo. Soon after the formation of the mandibular swellings, a similar antennal pair appear in front of them, and in front of the antennæ a single, median, unpaired swelling, the *front-head* (*Vorderkopf*). Antennæ and front-head show the same two layers as the other extremities. Behind the front head an invagination takes place—the beginning of the fore-gut. The front-head eventually gives rise to the clypeus and the labrum, and fuses with the lateral lobes which form the remainder of the head, excepting, of course, the mouth-parts.

The embryo now stretches itself so that the lateral lobes, instead of lying near the ventral surface of the egg, approach its posterior

* The amnion is the *viscerales Blatt* of Brandt, and the serosa is his *parietales Blatt*.

pole. Up to this period the embryo has occupied a reverse position to that in which it is found in later embryonic life. Its head end has been much nearer the posterior than the anterior egg pole, and its hind end nearer the anterior pole, while the appendages have been directed towards the dorsal egg surface (fig. 33E). The manner in which it changes its position will now be described.

Near the point where the amnion cavity was closed by the growth of the serosa, the amnion and serosa fuse together. The fused part tears. The torn right and left halves adhere to the dorsal egg surface. By contractions of the serosa, the yolk substance is drawn towards the anterior egg-pole, and this in turn forces the embryo, head first, through the rent. When this turning out is completed, the embryo lies with its head near the anterior pole, the appendages towards the ventral egg-surface, and the hind end of the abdomen, which is still folded ventrally on itself, towards the posterior pole. The ventral egg-surface, which was at first almost straight, is now also convex, owing to the increase in size of the egg-contents. The mandibles and first maxillæ lie transversely, the other appendages are directed backwards and somewhat towards the median line. The hind end of the abdomen bears three pieces, the beginnings of the tracheal gills, which conceal between them an invagination, which is the commencement of the hind-gut (fig. 34).

Brandt has given no detailed account of the remaining phenomena of embryonic development. He merely mentions that the segmentation of the body becomes more distinct, the appendages become jointed, teeth appear on the mandibles, the second maxillæ unite along their inner edges, the eyes appear, the cuticle becomes light brown, the yolk gradually disappears from the outside of the germinal band, its remainder being visible in the mid-gut.

When the embryo has reached its final position in the egg, the germinal band forms merely the ventral surface, the appendages and the greater part of the head of the embryo. The dorsal and much of the lateral parts of the thorax and abdomen are represented solely by amnion and serosa enclosing the remaining yolk in a sack. It is considered probable by Korschelt and Heider (18, p. 803), that the serosa part of this sack thickens, is invaginated into the yolk filling the sack, becomes constricted off, that its cells break up and mingle with the yolk, and that the walls of the yolk-sac are then furnished by the amnion alone. Whether the amnion is converted into the definite dorsal body-wall, or whether this is formed by lateral up-

growths of the germinal band is unknown. No account exists of the formation of the endoderm and mesoderm, or of the internal organs.

THE NYMPH.

The term *nymph* is here used to denote that stage of Odonate existence between the egg and the transformation into the imago. The length of time which elapses between the hatching of the egg and imagination (nymphal period), and the number of moults during that period, have not apparently been recorded for any species. It seems probable that the time extends over a considerable number of months, at least in the larger species, and that moulting occurs many times.

The nymph of *Anax junius*, just hatched, is 2 mm. long; the length of the nymph skin remaining after imagination is 45 mm. A nymph of this species obtained in August, 1888, moulted September 3d, the cast-off skin being 15 mm. long; it moulted again September 20th, the length of the exuvia was about 17.5 mm.; this nymph died before moulting again. According to Poletaiew (5), the rudimentary wing-covers only appear in Odonate nymphs after the third or fourth moult; both of these last mentioned exuviae show these covers. These facts appear to support the statement just made, although, of course, captivity may have retarded the rate of growth.

The **young nymph**, when hatched, is about 1 mm. long in *Libellula pulchella*, 2 mm. in *Anax junius*. In all the groups it is flattened from above downwards, the head is large and distinct, the three thoracic segments are clearly visible, and likewise the ten abdominal segments. The eyes are relatively small, and in all the groups are widely separated from each other. The antennae, on the contrary, are much longer than in the imago, being as long as the head in the young nymph of *Mesothemis simplicicollis*; they consist of three joints, of which the terminal one is much the longest, except in the legion *Calopteryx*. No ocelli are visible. Both mandibles and first maxillae are present, somewhat similar to those of the imago. The labium (second maxillae) has the form which is so characteristic of the Odonate nymphs (see Pl. II, fig. 8), and is known as the *mask*.* It is proportionally very much longer than in the imago. It consists of a basal piece (submentum), attached to the head, and which at its distal end bears a second piece (*m* and *ml*, fig. 8), corresponding to the mentum and median lobe of the imago together. The

* So-called from the circumstance that in many genera, *e. g.* *Libellula*, the lateral lobes are so large as to cover (mask) a great part of the face, when folded in rest.

distal extremity of this second piece bear at either angle, a lateral joint (*ll*), the lateral labial lobe of the imago. On the outer side of the lateral lobe is one or more articulated spines, of which the apical one (*tp*) is probably the free terminal joint of the labial palp, while on the inner side are teeth or spines (figs. 8, 9, 10). The submentum is directed backwards, and, in rest, lies in contact with the ventral thoracic surface, between the bases of the legs. The articulation of the submentum with the second piece is hinge-like, the latter being directed forwards. The planes of the lateral lobes are inclined to that of the second piece. The labium can thus be protruded to a considerable distance in front of the head, while the movement of the lateral lobes is from side to side, their teeth and spines completing the already formidable armament of the mask. The feet are very long in proportion to the body, thus giving a spider-like appearance to the nymph. Their main divisions are clearly expressed, and are sparsely clothed with hairs, but the joints of the tarsus are indistinct, and the tarsal nails are not toothed. Owing to the flattened form of the body, the bases of the legs of the right and left sides are much farther apart than in the imago. The shape of the abdomen varies in the different groups. At its hind end there are in the Zygoptera, three long, sparsely hairy, caudal tracheal gills, of which one is median and dorsal, the other two lateral and more ventral. In the Anisoptera, in the same positions as those occupied by the gills, are three chitinous pieces which act as valves to guard the anal opening. Between these three pieces—which are called middle and lateral appendages by Hagen—there is also in the Anisoptera, a pair of chitinous parts, which in life are constantly moving in a horizontal plane to and from each other in the process of respiration. Their function is probably to constantly renew the water in the rectum, in which are situated the rectal tracheal-gills. No traces of external genital organs are visible. The alimentary canal is complete, but there are as yet no salivary glands. Packard (19) distinguished the dorsal vessel in recently-hatched nymphs of *Diplax*, where the “flow of blood to the head and the return currents through the lacunar or venous circulation along the sides of the body are easily observed.” On either side of the body is a large longitudinal trachea (dorsal trunk?) from which branches proceed to the various parts of the body and the appendages, and are especially numerous in the rectal region. The ventral nerve cord and the cephalic ganglia are present; in the youngest nymphs of *Ischnura verticalis* and *Libellula pulchella*, the

writer finds eight distinct pairs of abdominal ganglia in segments 1 to 8; the last pair being the largest.

The subsequent changes which take place in the nymph up to the time of imagination, are as follows:

The relative increase in size of thorax and abdomen is much greater than that of the *head*, so that the latter, which, in the young nymph, was one-fourth or more as long as the trunk, in the last nymphal stage is only one-sixth to one-ninth of that length. The eyes soon become relatively larger, but never in any of the groups do they meet upon the top of the head. The epicranium is consequently of large size. The clypeus does not become differentiated into post- and ante-clypeus. The ocelli can be distinguished in old Agrionine nymphs at least. The long terminal antennal joint of the young nymph divides into a number of joints, in most of the subfamilies. Mandibles and first maxillæ closely approach the form of those of the imago. The labium throughout retains its large proportionate size; the shape of its lateral lobes is different in the young and old nymphs of the same species.

Thorax.—In the young nymph the prothorax is almost, or fully as large as either of the other two thoracic segments, but as the nymph increases in size, the meso- and metathorax become relatively larger, due to the development of the wing-covers and the wing-muscles. The wing-covers appear after the third or fourth moult (Poletaiew), as small triangular flaps, one on either side of the meso- and metanotum. They increase in size with each successive moult, are directed backwards, and lie upon the dorsal surface of the thorax and anterior abdominal segments, the hind wing-covers lying over and concealing the greater part of the front wing-covers; the courses of the chief longitudinal veins become quite apparent in the old nymphs. As the wing-covers increase in size, the right and left mesepisterna, which at first were entirely separate, extend dorsally and meet each other, first at the front margin of the mesothorax, their union extending gradually backwards towards the base of the front wing-covers. The boundaries of the pleural sclerites may be distinguished in the old nymphs. The bases of the legs remain quite far apart up to imagination; the length of the legs although great throughout nymphal life, is relatively less than in the first post-oval stage. The hairs which clothe the legs of the young nymph are soon lost; in their stead may be seen longitudinal rows of very minute spines, rudiments of those of the imago. Although the tarsi

of living Odonate imagos are universally three-jointed, and while most nymphs agree in this respect, the first and second tarsi of the nymphs of the Gomphinae are never more than two-jointed. The oldest nymphs rarely show any trace of the tooth on the tarsal nails.

The *abdomen* is always much shorter and broader than in the imago, and owing to its flattened form, the distinction between dorsal and ventral surfaces is much more evident. The pleura are equally well chitinized as the terga and the sterna; in the *Zygoptera* they are infolded, in the *Anisoptera* exposed to view on the ventral surface; the sterna are rectangular. Along the lateral margins of the segments a spine is frequently developed, the arrangement of which is often of generic character.

The three tracheal-gills which terminate the abdomen of the *Zygoptera* are, in the young nymph, conical, tapering gradually to the apex, longer than the abdomen and sparsely hairy. In *Colopteryx* they become triangular in cross-section; in the *Agrioninae*, each gill becomes a flat, thin plate; in both cases they enclose tracheal branches. Their relative length decreases.

In the *Anisoptera*, where, from the first, the places of the terminal gills are occupied by chitinous, non-respiratory appendages, the middle or dorsal appendage appears to be the shortest even at hatching. The pair of chitinous pieces, described as being constantly in motion in young *Anisopterous* nymphs, apparently disappears in early nymphal life. It is perhaps a fact of some significance that the hairs which are found in the youngest nymphs on the thorax, abdomen, legs, terminal gills in the *Zygoptera* or three terminal appendages in the *Anisoptera* are early lost.

The superior terminal appendages of the imago appear in the nymph at about the same time as the wing-covers, as a small conical process on either side of the dorsal gill or dorsal appendage. They increase in length with each moult, but never become as long as the gill or appendage between them. A comparison of recently transformed imagos and old nymphs indicates that the anal segment of the imago is formed by the representatives of the three caudal gills (*Zygoptera*) or appendages (*Anisoptera*) of the nymph. In the females (imagos) of both of these groups neither dorsal nor lateral pieces are greatly developed, and the anal opening lies between all three. In the males of the *Zygoptera* the two inferior appendages correspond in position to the two lateral gills of the nymph; the anal opening lies between them and is bounded above by a plate

corresponding to the dorsal gill. In the males of the Anisoptera the dorsal appendage of the nymph is represented by the single inferior appendage of the imago, and the two lateral appendages by the right and left halves of the tubercle in which the anus lies, below the inferior appendage. The inferior appendages of the males of the Zygoptera and Anisoptera are therefore not homologous.

The only external genital organs which appear in the nymphal period are to be found on the ventral surface of the ninth segment of older nymphs of the Agrionidæ, the Aeschninæ and the Cordulegasterinæ. The female nymphs of these groups may be recognized by the longitudinal ridges, which correspond to the form of the vulvar lamina and the genital valves of the imago. The old male nymphs of the Agrioninæ have two ventral hooks near the apex of 9, representing the two valves closing the orifice of the common duct of the testes. The same are also indicated by a slight eminence in male Aeschnine nymphs.

The information which exists as to the development of the internal organs is very little. The abdominal *muscles* form a more complete sheath than in the imago; they are well developed in the youngest nymphs. Poletaiew (5) believes the wing-muscles to be formed at the same time that the wing-covers first appear; they then are composed of globules similar to those of adipose tissue and interlaced with tracheæ, while all the other muscles are striated, as are the wing and remaining muscles of the imago. In consequence of the shape of the thorax, the wing-muscles of the nymph are more vertically placed at first, and subsequently change their direction in conformity with the increasing obliquity of the thorax.

The positions of the three parts of the *alimentary canal* correspond in older nymphs at least, to those of the imago, and the histological structure of the mid-gut is the same (Faussek 7). The characteristic features of the hind-gut will be referred to in connection with the respiratory apparatus. The time of the first appearance of the Malpighian tubules is unknown, but they are well developed in old nymphs.

The *respiratory apparatus* has been carefully studied by Oustalet (28) and Roster (30) in the nymph of the European *Aeschna cyanea* (*maculatissima*) and by Miss Olga Poletaiew (29) in those of *Ae. grandis* and *juncea*. Oustalet distinguishes three main pairs of tracheal trunks—dorsal, viseral and ventral, as already described for the imago of *Libellula pulchella*. The *dorsal* pair lie on the dorsal

surface of the alimentary canal in the head, thorax* and anterior abdomen, posteriorly they become more lateral. In the thorax they lie closely side by side, pass into the head, are connected by a cross trunk at the base of the brain, and then each bifurcates. In the middle of the thorax a cross-trachea connects the two dorsal trunks, and from this cross-trachea a branch is given off to the metastigma of each side. In the thorax each dorsal trunk gives off the following principal branches to its own side of the body: one to the mesostigma; one to the third leg; one which unites with a tracheal coming from the mesostigma, the common trachea running to the second leg; another tracheal runs from the mesostigma to the first leg, but on its way gives off a recurrent which runs forwards and underneath the œsophagus and unites with its fellow of the other side to form a loop, from which loop a branch runs forwards on either side below the œsophagus into the mask. In the abdomen each dorsal trunk is connected by six cross-tracheæ with the ventral trunk of the same side. The anterior end of each *ventral* trunk terminates in five branches in the hind part of the thorax; between the fifth and sixth of the cross-tracheæ connecting it with the dorsal trunk the visceral trunk unites with it, the common trunk continuing backwards and finally terminating in tracheoles. Anteriorly, each *visceral* trunk empties into the branch given off by the dorsal trunk to the second leg, but of the other side of the body. In *Aeschna cyanea* the visceral trunk unites posteriorly with the ventral trunk, but remains separate in *Diplax vulgata* and *Platetrum depressum*. Roster's figure of the tracheal system of *Ae. cyanea* agrees in the main with the preceding account of Oustalet, except that he shows each ventral trunk to run forwards to the mesostigma of the same side.

The writer has been able to verify many of the details of distribution given by Oustalet, in the nymph of *Lestes forcipata*. Here the dorsal trunks are six or more times larger in calibre than the visceral or ventral trunks. In the hind part of 9, each dorsal trunk bifurcates, the more lateral branch supplies the lateral caudal tracheal-gill, the upper joins its fellow of the other side in the dorsal caudal tracheal-gill. Each visceral trunk empties anteriorly into the branch to the third leg of the other side of the body.

* Compare the account given of the dorsal trunks for the imago of *L. pulchella*, p. 179. The significance of this difference is unknown.

The chitinous lining of the rectum of the Anisopterous nymphs is modified so as to present the appearance of six longitudinal bands, *rectal tracheal-gills*. Each of these tracheal-gills consists of two rows of thin lamellæ in the Libellulidæ, of two rows of villous tufts in *Aeschna cyanea* (Oustalet), or of two rows of lamellæ, similar to, but of different shape from those of the Libellulidæ, in *Aeschna grandis* and *junceæ* (Miss Poletaiew). Into each lamella, or into each papilla of each tuft, run one or more tracheals and split into tracheoles, which run to the apex of the lamella or papilla, recurve and anastomose with efferent twigs.* The lamellar or papillar tracheals are derived, according to their situation, from a dorsal or a visceral trunk. Each dorsal trunk gives off nine or ten cross-tracheæ to each of the upper two rectal tracheal-gills of its own side of the body, while the lowermost (ventral) gill is supplied by about eight cross-tracheæ from the visceral trunk of the same side (Oustalet). The epithelium of the hind-gut of an *Aeschna*-nymph has been studied by Faussek (7), who finds it to be of two kinds, sharply distinct from each other: 1, of large cells and nuclei; 2, of small cells and nuclei. No regularity in their distribution exists; the smaller cells are found in compact, involved folds, the larger where there are none or only simple, isolated folds. At the extreme hind end of the rectum are six rectal glands, from the simultaneous presence of which, with rectal gills, Faussek concludes with Chun (Abh. Senckb. Natf. Gesell. x, pp. 27-55) in opposition to Gegenbaur, that rectal glands are primitive, rectal gills secondary. The rectal tracheal gills are not carried over into the imago (Hagen 27), but as previously mentioned, their vestiges persist. The rectal chamber may serve both for aquatic and for ærial respiration, and, by violently ejecting its contained water, for propulsion, and apparently for defense (Miss Monks, Am. Nat. xv, p. 141).

The existence of three rectal-tracheal gills in *Calopteryx*, announced by Dufour (Compte Rendu, l'Acad. Sci. T. 29, pp. 764-7, 1849), though denied by Miss Poletaiew (29), has been reaffirmed

* Such is the account given by Oustalet. Macloskie states that the ultimate tracheal ramifications in these lamellæ end cæcally, and that the "action of the tracheæ is tidal rather than by peripheral capillary circulation" (Psyche iv, pp. 111, 112, 1883). The results of the writer's examination of the lamellæ of a Libellulid nymph and of the caudal tracheal-gills of *Lestes* agree with those of Oustalet. As, however, the recurrent tracheoles become connected with the twigs from which the efferent tracheoles arise, the peripheral capillary circulation, if there be such, must be confined to the loops alone.

by Hagen (27). Dufour (*l. c.*) regarded the caudal tracheal-gills of *Calopteryx* merely as "swimmerets or oars," and although they do serve this purpose, yet the middle tracheal-gill is well supplied with tracheals and apparently functions as a respiratory organ. The nymphs of the Calopterygine genus *Euphæa* are remarkable in that they possess three *functional* caudal tracheal-gills, three rectal tracheal gills, and an external, conical tracheal-gill on each side of the first eight abdominal segments (Hagen 52).

The thin caudal tracheal-gills of the Agrioninæ are well supplied with tracheæ, but as the nymphs live after these are removed, Dewitz (25) suggests that here also the rectum may perform respiratory functions. No rectal tracheal-gills, however, have been found as yet in this subfamily, although the rectal walls are well supplied with tracheæ.

There are ten pairs of spiracles, as in the imago, and similarly distributed. They are all open, but those of the abdomen are probably not functional (Hagen 27, 52). The thoracic stigmata become functional at an earlier period in the nymphal life of the Agrionidæ and Libellulidæ than of the Aeschnidæ, but in all three cases only on one side of the body (Dewitz 25).

The *nerve-ganglia* occupy the same positions in the old nymphs as in the imago. In a Libelluline nymph, genus unknown, the writer found the meso- and metathoracic ganglia distinct, although nearer to each other than the former to the prothoracic pair; the same nymph had the testes well-developed. While each of the first eight abdominal segments of the young nymphs of *Ischnura verticalis* and *Libellula pulchella* has a pair of ganglia, all old nymphs, as far as known, have seven pairs as in the imago. In what way the reduction is effected is unknown, but the result is to leave the second abdominal segment without ganglia of its own (see p. 183).

The nymphs are ordinarily not very active, although when disturbed they can move quite rapidly, those of the Zygoptera by a serpentine movement of the abdomen, those of the Anisoptera by a series of "jerks," propelled by the water ejected from the rectum. Most of this period is spent clinging to the under surface of plants, sticks and stones, relying on a cautious approach and a sudden movement of the mask to obtain their living food.*

The food of the nymphs has already been considered in connection with the alimentary canal of the imago, p. 177.

Still greater inactivity precedes the moults of the nymphal period, which are accomplished in the water. The fissures by which the nymph emerges from the exuvia are two, a transverse dorsal curved fissure passing across the top of the head through the middle or in front of the eyes, and a median longitudinal dorsal fissure extending from the first fissure as far back as the base of the hind wing-covers. The exuvia remains in one piece. From his studies on Odonate nymphs, Chatin (23) concludes that the "epidermal cells produce the chitinous coat not by secretion, but by a special process, which is to be considered as a direct emanation of their protoplasm transforming itself into chitinified strata."

When the time for the final transformation (imagination) arrives, the nymph crawls out of the water upon some object. The skin splits in the same lines as described above. In the Agrioninæ, at least, the first part of the imago to emerge is the anterior portion of the thorax, then the head, the feet, the wings and the abdomen. The last two are of course much smaller at this time than they will be. The imago lingers near where the transformation has taken place, until the wings and abdomen are stretched to their full extent. Bellesme (22) thinks, from his observations on *Platetrum depressum*, that this inflation is accomplished by swallowing air and storing it in the alimentary canal.

The nymph-skin, left attached to the object by its feet, almost perfectly preserves its size and shape, and sometimes closes at the fissures so as to quite conceal them. The following measurements give the size of a nymph-skin and of the fully expanded imago, a female *Anax junius*, which came from it, the first dimension in each case being that of the exuvia:

Total length (including appendages) 45 mm., 67. Length of the head 7, 7. Greatest height of head 3.5, 8.5. Length of thorax 8, 14. Length of abdomen (incl. app.) 32.5, 46. Length of hind wing (cover 8.5), 49. Length of third femur 7.5, 10.

In recently transformed imagos the colors are pale, and a yellowish hue predominates; such are called *teneral* imagos. The characteristic color of the species appears after some hours. A sign of increasing age is a bluish or whitish powder, which appears on the body, especially of the males, and is known as *pruinoseness*. While the colors of the nymphs are dull, in harmony with that of their surroundings, and therefore protective, those of the imagos are usually bright, attractive and frequently brilliant.

The range of size of Odonate imagos extends from *Agriocnemis minima* Selys, of Java, whose abdomen measures 13.5 mm., the hind wing 8.5 mm.—to the Central American *Megaloprepus caerulatus* Drury (ab. 102, hind w. 94) and the South American *Mecistogaster amalia* Burm. (ab. 130, h. w. 85). The three species named are all Agrioninæ and have very slender bodies. The largest robust species is *Gynacantha plagiata* Waterh. (ab. ♂ 90, ♀ 67, hw. ♂ 65.5, ♀ 81), an Aeschnine of Borneo and Sumatra.

3. DISTRIBUTION OF THE ODONATA.

CONDITIONS DETERMINING DISTRIBUTION.

Nature of the water in which the nymphs live.—Owing to the aquatic life of the nymphs, the imagos absolutely must spend at least a portion of their lives in the neighborhood of fresh, or at the most, brackish water. No Odonate nymphs are known to live in salt water, but probably some coast species, such as *Ichnura Ramburii* and *Micrathyrja berenice*, live in that which is brackish. Schwarz observed nymphs in shallow pools of mixed salt and sulphurous or fresh water on the flats near Great Salt Lake, Utah, and in sulphur creeks (Can. Ent. xxii, pp. 238–9).

Temperature.—Considerable heat is required for imagination, for activity during, and for the very existence of, imaginal life. Even in temperate climes the Odonata are only active in warm weather, cool, cloudy days in Summer causing them to take refuge in grass and foliage. Only one species of Odonata—the European *Sympycna fusca* Vander L.—is known to regularly hibernate as an imago in numbers (René Martin, Rev. Sci. Bourb. i, pp. 53–57), although some few imagos of *Diplax* do so. This ability means a greatly increased length of imaginal life, which for most Odonata varies from 25–45 days, but in *S. fusca* becomes nearly seven months (Martin). In the great majority of cases the Winter is probably spent in the nymphal state.

Checks to Increase.—Negative checks to increase may be due to the drying up of the water in which unhatched eggs have been placed, or to low temperature; the eggs do not seem to be well adapted to resist unfavorable conditions, judging from those reared in glass jars, although McLachlan found *Agrion mercuriale* ovipositing in soft mud where the water had evaporated. Positive checks are furnished by those animals which devour or injure the Odonata in different stages. Brandt (18) found more than half the eggs of *Calopteryx*

virgo in the river Wieseck, near Giessen, to be infested with the larvæ of *Polynema ovulorum* L., a minute Hymenopter of the family Chalcididæ. Minute Diptera and Acarina also oviposit in or devour the eggs (Mrs. Aaron 54, p. 50). These and the young nymphs provide food for fishes* and other aquatic animals; added to this is the cannibalism of the nymphs (see p. 178). The writer has found a young spider, kindly identified by Dr. McCook as *Dolomedes sex-punctatus* Hentz, feeding upon the soft parts of recently transformed imagos of *Ischnura verticalis* and *Nehalennia posita* which were not yet able to fly. The carnivorous habits of the Odonata naturally expose them to the entrance of intestinal parasites, and de Selys has recorded the finding of a *Filaria* in the abdomen of *Diplax flaveola*, inflating it to such an extent as to impede the insect's flight (Rev. Odon. d'Eur. p. 36). Red Acarina (mites) frequently occur on the thorax and abdomen of imagos, especially on the ventral side, and have been mistaken for eggs; a male of *Mesothemis simplicicollis*, communicated by Mr. H. F. Moore, had upwards of 100 such mites attached to the ventral surface of the sixth and seventh abdominal segments. During oviposition the female dragonfly sometimes falls a prey to fishes. Lastly, dragonflies are eaten by various kinds of birds.

Fisher (U. S. Dept. Agric. Div. Ornith. and Mam. Bull. No. 3, 1893) records the following Falconidæ as feeding on the Odonata in the United States: Swallow-tailed Kite (*Elanoides forficatus*), Sharp-shinned Hawk (*Accipiter velox*), Red-shouldered Hawk (*Buteo lineatus*), Broad-winged Hawk (*Buteo latissimus*), Duck Hawk (*Falco peregrinus anatum*), Pigeon Hawk (*Falco columbarius*) and Sparrow Hawk (*Falco sparverius*); none of these live exclusively upon dragonflies. Müller (Proc. Ent. Soc. Lond. 1871, p. xlii) quotes Natterer, who found "Libellen" in the stomach of a South American Falconid, *Hypotriorchis rufigularis*. In central France, "from May to September, in the pond countries where Odonata are naturally common, the Hobereau (*Falco subbuteo*) lives almost exclusively on the large Aeschnids, while the *Hydrochelidons* eat hardly anything but Agrions. Certain other birds also attack the Libellulæ at times, but none of them, even for a short season, make their exclusive diet thereon" (René Martin: Bull. Soc. Ent. France, 1891, pp. clxix-xxi). Gould states that he has frequently seen small birds, sparrows, etc., capture and eat the small species of Odonata frequenting the sedgy banks of the Thames (Proc. Ent. Soc. Lond. 1871, p. xlvii). Both Martin and Gould mention that the dragonflies were deprived of their wings before being eaten by the birds. Hersey (Can. Ent. v, p. 160) found the King-bird (*Tyrannus carolinensis*) feeding upon Odonata in New Hampshire. Starlings, blackbirds and sparrows fed on a swarm of Odonata at Dresden, seen by Weid-

* Forbes gives a list of fishes in whose alimentary canals nymphs were found (Bull. Ill. State Lab. Nat. Hist. ii, p. 524).

inger (Ent. Nach. vii, p. 187). The Egyptian Bee-eater (*Merops persicus*) includes dragonflies in its diet (Allen, Ibis, 1862, p. 360).

Means of Distribution.—The highly-developed power of flight possessed by the Odonata constitutes a most efficient means of distribution, to which must be added the important aid afforded by the winds. Migratory swarms composed of many individuals of one or more species have frequently been observed. Köppen has brought together the records of sixteen migrations from 1494 to 1868 (Stett. Ent. Zeit. 1871, pp. 183–90), and Beutenmüller (54, pp. 161–2) adds twenty-six instances, mostly between 1872 and 1888. Representatives of the Calopteryginae, Agrioninae, Aeschninae and Libellulinae have taken part in such migrations, but the chief migratory species is *Libellula quadrimaculata*, swarms of which have been met with both in Europe and in North America. Annual migrations of this species occur in the Charente Inferieure according to Riveau, and a similar statement is made by Brown for *Aeschna eremita* (= *clepsydra* Say, see *post*) in Wisconsin. The cause of these migrations is unknown; in some cases they are believed to be due to the drying up of ponds, but this explanation does not appear to account for all the known instances.

Dragonflies have frequently been met with flying over the ocean, many miles from land, so that bodies of water of moderate size do not offer barriers to their dispersal. The observations of Schwarz (Proc. Ent. Soc. Wash. i, p. 208–15) lead to the conclusion, however, that many individuals do fall into the water and so perish.

The number of eggs laid by a single female is very variable, but often amounts to several hundreds, and each imago pairs more than once. As a considerable number of eggs are usually laid in each body of water, a number of imagos is to be expected at that locality, for at least a short period after imagination. Eggs and nymphs, however, are probably frequently transported from one place to another by currents of water.

GEOGRAPHICAL DISTRIBUTION.

The Odonata are found over nearly all parts of the world, being, of course, more numerous in the tropics. Nowheres are they known to pass beyond the northern and southern limits of permanent human habitation, as these are shown by Bartholomew (Hand Atlas), but they probably occur above the northern limit of trees. The most northern localities known for these insects are near Alten, in Fin-

mark, Norway, 70° N., for *Somatochlora arctica*; Norton Sound, Alaska, 65° N., for *Aeschna juncea*; and the Wilui River, Siberia, 60°–63° N., for *Aeschna crenata* (*clepsydra*), *Leucorhinia rubicunda* and other species. The annual isotherm of 0°C. (32° F.) passes above the first of these places, but below the other two, while a portion of the Wilui River is above the annual isotherm of –10° C. (14° F.). Baron de Selys mentions a wing, considered by McLachlan to belong to *Somatochlora metallica*, collected by the Nordenskiöld expedition at Port Dickson, near the mouth of the Jenesei, 73° 30' N., but there is no knowledge as to whence it may have been carried by wind and wave. The most southern point at which dragonflies have been found is Bay St. Bernard, Hoste Island, Fuegian Archipelago, 55° 30' S. for *Aeschna diffinis* Ramb. (Mabille), which, in point of temperature, does not compare with the northern locations mentioned.

Odonata occur in the mountainous regions of the world, but comparatively few precise records exist as to the elevations which they attain. *Allogaster latifrons* and *Cephaloeschna orbifrons* have been taken at 10,000 ft. at Phulloth, in Bengal, *Ophiogomphus severus* at 9600 ft. in Colorado, *Epigomphus subobtus* and *Cordulegaster Godmani* on the volcano of Irazu, Costa Rica (6000–7000 feet) and *Camicinia harterti* on Mt. Deli, Sumatra (8000 feet).

The number of described species of Odonata at the present writing (July, 1893) is shown in the following table:

SUBFAMILIES	Living throughout the world		Fossil throughout the world	
	genera	species	genera	species
Calopterygineæ.....	33	239	3	6
Agrioninæ.....	88	605	7	28
Gomphinæ.....	46	254	10	28
Cordulegasterinæ.....	5	27	1	3
Aeschninæ.....	23	126	2	12
Cordulinæ.....	22	146	1	2
Libellulinæ.....	104	525	3	26
Total.....	321	1922	27	105

The distribution of the living forms in the various zoö-geographical provinces is shown on the next page in a table which has been prepared for this paper by the writer's brother, Mr. Frederic B. Calvert; it is based on Kirby (35), but with the addition of such species as have been described, and corrections made since the publication of that Catalogue.

TABLE SHOWING THE TOTAL NUMBER OF GENERA AND SPECIES OF ODONATA OF EACH ZOO-GEOGRAPHICAL PROVINCE,
WITH THE NUMBER OF GENERA AND SPECIES PECULIAR TO EACH.
PREPARED ESPECIALLY FOR THIS PAPER BY MR. FREDERIC B. CALVERT.

SUBFAMILIES.	Neotropical			Nearctic			Palearctic			Ethiopian			Oriental			Australian.			Polynesia					
	Total		Peculiar	Total		Peculiar	Total		Peculiar	Total		Peculiar	Total		Peculiar	Total		Peculiar	Total					
	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.				
Calopteryginae.....	10	96	9	88	2	18	0	17	6	26	1	25	5	17	1	16	16	88	9	84	4	11	0	0
Agrotinae.....	40	219	28	188	12	56	0	47	14	73	0	71	22	59	10	59	26	125	8	117	21	65	9	61
Gomphinae.....	15	60	10	55	9	50	2	49	12	52	0	51	12	26	7	25	15	59	6	59	5	11	0	0
Cordulegasterinae....	4	8	3	7	1	8	0	7	2	10	0	10	0	0	0	3	3	3	3	3	0	0	0	0
Aeschninae.....	9	43	3	31	6	24	2	15	7	30	3	24	5	16	1	15	9	23	3	20	8	11	3	9
Cordulinae.....	4	12	3	11	7	34	4	34	7	16	2	16	5	12	3	12	5	15	1	16	8	22	4	21
Libellulinae.....	41	132	22	109	17	68	2	56	20	85	4	74	32	87	15	79	36	123	5	99	30	73	9	53
Totals	123	570	78	489	54	258	10	225	68	292	10	271	81	217	37	206	110	436	32	398	76	193	28	164

G. = genus. Sp. = species.

The limits of the provinces employed in the above table are as follows:

Neotropical: Tropical Mexico, Central America, West Indies, South America and the adjoining islands.

Nearctic: America north of Mexico.

Palearctic: Europe, Asia north of the watershed of the Yang-tse-Kiang and the Himalayas and west of the Indus, Africa and Arabia north of the Tropic of Cancer, and the islands immediately adjoining these countries, Japan, etc.

Ethiopian: Africa and Arabia south of the Tropic of Cancer, Madagascar and the adjacent islands.

Oriental: Asia east of the Indus and south of the Himalayas and the watershed of the Yang-tse-Kiang, Ceylon, Sumatra, Java, Borneo and the Philippines.

Australian: Australia, Tasmania, New Zealand, New Guinea, Celebes and the intervening islands.

Polynesian: The islands of the Pacific from the Australian province on the west as far east as and including the Sandwich Islands, the Marquesas and the Low Archipelago.

The Calopteryginæ are most abundant in the Neotropical and Oriental provinces, but the most widely distributed genus is *Calopteryx*, which is Palaearctic and Nearctic. None of this subfamily are Polynesian.

The Agrioninæ are cosmopolitan; the genera *Lestes* and *Ischnura* are world-wide, *Argia* is of both Americas and the Kurile Islands, *Agrion* is Palaearctic, Nearctic and Oriental, *Pseudagrion* and *Disparoneura* are of the Old World from West Africa to Australia and Borneo, and the most widely distributed species is *Enallagma cyathigerum* of the upper parts of Europe, Asia and North America.

No Gomphinæ are Polynesian. *Gomphus* occurs throughout the northern hemisphere.

The Cordulegasterinæ are Neotropical, Nearctic, Palaearctic and Oriental. *Cordulegaster* ranges through the northern hemisphere.

The Aeschninæ and two genera thereof, *Anax* and *Aeschna*, are cosmopolitan. *Gynacantha* is of the tropical and subtropical regions around the globe.

The Cordulinæ and Libellulinæ are world-wide. Of the former *Somatochlora* extends throughout the cooler parts of the northern hemisphere. Among the latter are *Pantala flavescens*, the most widely distributed species of Odonata, being found in America, Asia, Africa and the Pacific (see Part II); *Orthetrum*, of all parts of the Old World, *O. sabina* ranging from the Fijis to the Cameroons; *Libellula quadrimaculata* and *Diplax scotica* of the upper parts of the northern hemisphere; and *Crocothemis erythræa* of Southern Asia, Europe and Africa.

GEOLOGICAL DISTRIBUTION.

Fossil remains of Odonata have been found as far down as the Lower Lias in England and Germany, although two fragments of wings from the Devonian of New Brunswick and named by Scudder *Platephemera antiqua* and *Gerephemera simplex*, really belong to the Odonata according to Hagen (Bull. Mus. Comp. Zool. viii, pp. 276, 277).

According to Kirby (35) the beds which have yielded them are in England the Lower Lias of Strensham, Binton and Cheltenham, the Upper Lias of Dumbleton, the Purbeck of Swanage and the Vale of Wardour; in France the Eocene of Provence and the Miocene of Auvergne; in Germany the Lower Lias of Schambelen, the lithographic slates (Oolite) of Solenhofen, Eichstatt and Pappenheim, and the Miocene of Oeningen, Schossnitz, the Brown coal of Rott and Sieblos, the amber of East Prussia; in Italy, the Eocene of Monte Bolca; in Croatia, the Oligocene of Radaboj; in the United States the Eocene of the Green River shales of Wyoming, and the Oligocene of Florissant and Roan Mountains, Colorado; in Queensland, the Cretaceous.

The Calopteryginæ are represented in the lithographic slates by the living genus *Euphea* and the extinct *Isophlebia* and *Tarsophlebia*. Of the Agrioninæ are the living genera *Agrion* (Solenhofen, Florissant, Amber, etc.), *Megapodagrion* (Green River), *Trichocnemis* (Florissant), and *Lestes* (Radaboj, Oeningen, Sieblos) and the extinct *Dysagrion* (Green River), *Lithagrion* (Florissant) and *Agrionidium* (English lower Purbeck). Belonging to the Gomphinæ are the living *Gomphus* (Vale of Wardour, Amber), *Gomphoides* (Dumbleton, Amber), *Ictinus* (Rott) *Uropetala* (lithographic slate) and *Petalura* (id., Sieblos), and the extinct *Protolindenia*, *Stenophlebia*, *Cymatophlebia* (all lithographic stone), *Heterophlebia* (English

Lias, lithographic stone, Sieblos) and *Stenogomphus* (Roan Mountain). *Cordulegaster* occurs in the lithographic stone. *Anax* (Radoboj) and *Aeschna* (Schambelen, lithographic stone, Wardour, Queensland Cretaceous, Florissant, Oeningen, Rott) are living Aeschninæ. Radoboj and Monte Bolca have yielded the living *Cordulia*. Lastly, for the Libellulinæ are the extinct *Aeschnidium* (Swanage, lithographic stone) and *Libellulum* (Swanage, Wardour), and living "*Libellula*" (English Lower Lias, lithographic stone, Provence, Auvergne, Oeningen, Schossnitz, Rott).

The oldest Odonate remains are therefore of the Gomphinæ, Aeschninæ and Libellulinæ from the Lower Lias. The Calopteryginæ, Agrioninæ and Cordulegasterinæ are first found in the Oolite. The oldest known Cordulinæ are of Eocene age. The value of this paleontological evidence will be discussed later.

4. RELATIONSHIPS OF THE ODONATA.

RELATIONSHIPS TO OTHER INSECTS.

The insects to which the Odonata are most nearly related, are the Ephemera and the Perlina. All three groups, besides passing through an incomplete transformation, agree in the possession of three ocelli, numerous Malpighian tubules, and of aquatic nymphs which breathe by tracheal-gills.

The Odonata and the Ephemera constitute the Subulicornia of Latreille, by reason of their short, subulate (awl-shaped) antennæ; other agreements are the relatively small size of the prothorax to the other thoracic segments in the imago, but not in the nymph, and the absence of a part which may be closed as a fan in the hind wings—characters which are the opposite of those of the Perlina. The three terminal jointed setæ of the Ephemerine nymphs, clothed with short bristles, recall the three caudal, though jointless,* tracheal-gills of the nymphs of the Zygoptera, which at hatching are setiform and sparsely hairy, and in the Calopterygine genus *Euphæa*, remain setiform and hairy for at least the apical half of their length. The nymphs of *Euphæa* also have a lateral gill on each side of abdominal segments 1-8, another resemblance to the Ephemerine nymphs in which such gills exist on 1-7. But in almost all other respects the Ephemerina differ from the Odonata in that their imagos have their mouth-parts more or less atrophied and functionless, the tarsi four- or five-jointed, the wings of unequal length, the venation different, the terminal abdominal appendages (setæ) jointed, and want the characteristic separated accessory genital organs of the male Odonata.

* Nymphs of *Lestes* show traces of an articulated structure in the stems of the caudal tracheal-gills.

With the *Perlina* the Odonata have little more in common than as stated above; however, the former have three-jointed tarsi and the mouth-parts function as biting organs, although in structure they are quite different from those of the Odonata; the *Perlina* have eight pairs of abdominal ganglia.

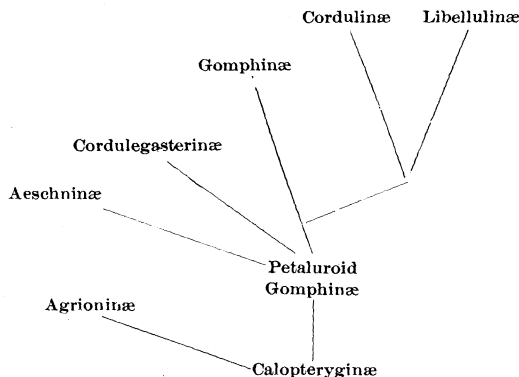
While, therefore, the Odonata are more nearly related to the Ephemera, the differences separating the two groups are still considerable.

As the common ancestral form of the *Perlina*, Ephemera and Odonata, Mayer suggested the *Protamphibion* characterized by having eleven free abdominal segments, prothorax freely movable, head fixed, biting mouth-parts, wings equal, three ocelli, tarsi five-jointed, three thoracic and seven abdominal ganglia, 20-50 Malpighian tubules, no ovipositor (legescheide); development with internal germinal band, larva with three pairs of legs, similar to the imago (Jen. Zeit. Naturw. x, p. 202, 1876).

The Odonata also possess primitive Insectan features in that the embryo is developed from an invaginated germinal band, recalling the manner of development of the Myriapods (Korschelt and Heider 18), and in the preservation throughout life of ten distinct abdominal segments with a terminal anal segment—a number which appears to be constant for the early embryonic stages of all insects.

RELATIONSHIPS OF THE ODONATE GROUPS TO EACH OTHER.

The writer's view of the relationship of the subfamilies of the Odonata to each other may be best expressed by the accompanying diagram, in which the Calopteryginæ are represented as the most



primitive and least specialized. That at least some Calopteryginæ are less specialized than all the other Odonata, or in other words differ less from other Insects, seems to be indicated by the simulta-

neous possession of the following structural features: for the imago, the relatively less extent of the eyes, the less degree of fusion shown in the labium, the completeness of the first lateral thoracic suture (*i. e.* a less intimate union of meso- and metathorax), and the distinctness of meso- and metathoracic ganglia; for the nymph, a greater resemblance to Ephemerine nymphs by the possession of three, originally setiform, caudal tracheal-gills, and of lateral abdominal tracheal-gills (*Euphæa*).

If this starting point be accepted, the Agrioninæ, admittedly the nearest allies of the Calopteryginæ, form a group having no relationship to the other subfamilies save by a common descent from Calopterygine ancestors. Approaches to connecting forms between the two groups are furnished, as De Selys (40) long ago suggested, by the exotic Calopteryginæ *Amphipteryx* and *Micromerus*. Of the Agrioninæ, the legion Lestes stands nearest the Calopteryginæ by the point of origin of its subnodal and median sectors. The legion Agrion is the most specialized of its subfamily; of its genera, *Argia* is probably the oldest phylogenetically, and the line of descent from it may run through *Agrion*, *Enallagma* or *Nehalennia*, and *Ischnura* to *Anomalagrion*. With such a phylogenetic series the views of Kolbe (3) agree—that the male appendages, which are the essential supports in copulation, gradually lose their relative size; that to supply this deficiency emarginations and lobes are formed on the hind margin of the prothorax of the female, and that in accommodation to the shape of this last, the tenth segment of the male becomes emarginated or provided with bifid processes.

Of living Anisoptera, the Gomphinæ of the legion Petalura of Selys most nearly approach the Calopteryginæ in that they have the eyes separated, the median lobe of the labium bifid, the vulvar laminae formed as an ovipositor and with genital valves. We know nothing of their nymphs. There are but four living genera, *viz.*: *Petalura* with one species from Australia, *Uropetala* with one species from New Zealand, *Tachopteryx* with two species from the United States and one from Japan, and *Phenes* with one species from Chili. Four fossil species have been referred to *Uropetala* and three to *Petalura* (Kirby 35).

Derived from Petaluroid forms, three lines of descent may be conceived. One of these is that of the Aeschninæ which preserve the ovipositor, the genital valves and the distinctness of meso- and metathoracic ganglia, but in which the median labial lobe is entire, the

eyes are united on the top of the head, and the abdomen develops lateral longitudinal carinæ; here are the most powerful in flight of all Odonata.

As a second line from the Petaluroid forms, come the Cordulegasterinæ;* here the median lobe of the labium remains cleft, the eyes, although often meeting dorsally, do so only in a single point, but the genital valves disappear.

Thirdly are the bulk of the Gomphinæ which ultimately have the median labial lobe entire, lose the genital valves and the ovipositor, have the meso- and metathoracic ganglia united, but preserve the primitive characters of separated eyes and absence of lateral abdominal carinæ.

From some point along the Gomphine line, the Libellulidæ can be conceived as having arisen. From Gomphine ancestors they inherited the absence of an ovipositor, and perhaps the union of the last two thoracic ganglia; the eyes meet upon the top of the head, the labium loses all trace of the bifid (bilateral) character of the median lobe, which is quite small as compared with the lateral lobes; a change takes place in the venation of the wings, so that the triangle of the front wings is elongated in the direction of the short axis of the wing, and the triangle of the hind wings (in the more specialized genera) although retaining its direction of elongation, comes to lie with its inner side in the prolongation of the arculus; and lateral carinæ appear on the abdomen. The relationship between the two subfamilies of the Libellulidæ is not yet apparent; the most important systematic character separating them is a small tubercular projection present on the hind margin of the eyes of the Cordulinæ. Perhaps we are to look upon such Corduline genera as *Somatochlora* as the most specialized of all the Odonata.

The preceding view of the relationships of the various groups to each other is based entirely on morphological evidence. There is, apparently, only one important morphological fact which is not in favor of regarding the Calopteryginæ as the most primitive group, and that is that these dragonflies have an ovipositor, while neither the Perlina nor the Ephemerina possess such. For this reason Mayer regarded the Libellulidæ as most approaching the hypothetical Protamphibion, one of whose characters (see above) was "no ovipositor;" he consequently looked upon the Agrionidæ on one hand and the Aeschnidæ on the other, as derived from a Libellulid stock. If the Protamphibion did not have an ovipositor, to look upon the Calopteryginæ as the writer does, means that the Gom-

* Here and elsewhere throughout this paper the subfamily Cordulegasterinæ is equivalent to the legion Cordulegaster of Selys alone, and not of the extent of the Division Cordulegasterina of Kirby (35).

phinæ and Libellulinæ have reverted to the far back ancestral peculiarity in this respect. On the other hand, to accept Mayer's view means that the ephemere appearance of the nymphs, the separation of the eyes, the cleft labium, the completeness of the first lateral thoracic suture, and the distinctness of the last two thoracic ganglia of the Calopteryginæ are all reversions. If the absence of an ovipositor really be of great importance, the Gomphinæ ought to offer more primitive characters than the Libellulidæ, but the view taken above seems the most satisfactory to the writer.

No embryological evidence for the solution of the question exists as yet. The paleontological evidence, as already set forth, tells of the existence of Libellulinæ, Gomphinæ and Aeschninæ in the Lower Lias, and nothing of the Calopteryginæ until the Oölite, but at the meeting of the Entomological Section of the Philadelphia Academy of Natural Sciences, held May 25, 1893, at which the writer brought the matter up for discussion, Dr. S. H. Scudder expressed the opinion that the scantiness of fossil Odonata did not give weight to any negative arguments based on their non-discovery.

The writer had written the above statement of his views of the phylogeny of the Odonata before he had read the brief expressions of Kolbe and Redtenbacher tending to the same opinion. Kolbe (Berl. Ent. Zeit. xxviii, p. 393, 1884) says of the "Agrioninen" that they are of the lowest stage of Odonate organization by their separated eyes, prothorax still moderately large, almost equal wings, pterostigma differing rarely from the other cells, and external tracheal-gills in the larvæ. Redtenbacher writes "While it seems doubtful to me to look upon the Gomphidæ as the oldest forms of the Odonata, I think that I recognize in the wing of *Calopteryx* that form from which the wing-forms of the other Odonata are derived" (Ann. k. k. Naturhist. Hofmus. Wien, i, p. 167, 1886).

Note on the Preservation of Specimens.

For the ordinary systematic collection of dried Odonata, it is *always* advisable to insert in every specimen, when it is mounted a bristle, or a fine non-corrosive wire, beginning at the nasus and passing it through the entire length of the body, but not allowing it to project beyond the eleventh (anal) segment. This holds the various parts of the body together. The thickness of the bristle should conform to the size of the specimen. If it be desired to preserve the coloring of the body, it is of some advantage to make a longitudinal cut on the ventral surface of the abdomen and even the thorax, remove the contents, and insert a wad of cotton; in doing so, the body wall must not be rubbed or scratched by the instruments employed. Some specimens of each species should always be preserved intact, as the cutting usually destroys or distorts some of the abdominal structures, which are of more importance for study than the colors. Nymphs and specimens for dissection may be preserved by killing them, or placing them immediately after death, in hot, but not boiling alcohol of 50 to 60 per cent. for three or four hours, then transferring them to (cold) alcohol of 75 to 80 per cent. in which they may be kept indefinitely. *N. B.*—The vessel containing the alcohol to be heated must be placed in another vessel containing water and thus heated indirectly to avoid the danger of explosion. For methods of technique for histological purposes, recourse must be had to the histological papers quoted in the Bibliography.

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PART II.

CATALOGUE OF THE ODONATA OF THE VICINITY OF PHILADELPHIA.

CHARACTERS OF THE MAJOR GROUPS.

SUBORDER I. ZYGOPTERA.—Front and hind wings similar in shape or nearly so, usually elevated in repose; no membranule; with an unmodified quadrilateral. Males with two inferior, terminal, abdominal appendages, penis and its vesicle separate. Nymphs with three caudal tracheal-gills.

FAMILY 1. AGRIONIDÆ.—Head transversely elongated; eyes separated from each other; lateral lobes of the labium of two* joints, middle lobe bifid. Females with genital valves.

Subfamily 1. Calopteryginæ.—At least five, and usually more antecubitals.

Subfamily 2. Agrioninæ.—Two, occasionally three, antecubitals, wings stalked at base, quadrilateral not cross-veined (except in the S. Amer. *Anomisma*).

SUBORDER II. ANISOPTERA.—Wings dissimilar, hind wings usually broader at base; horizontal in repose; usually with a membranule; quadrilateral modified to form a cardinal cell (triangle) and a supratriangle. Males with one inferior, terminal, abdominal appendage, penis and its vesicle connected. Nymphs without caudal tracheal-gills.

FAMILY 2. AESCHNIDÆ.—Triangles of front and hind wings of similar shape (except in some Gomphinæ). Antecubitals of first and second series not coincident, except the first and one other (the latter is variable in position), which two are thicker than their fellows. Postcubitals in the entire second series. Lateral lobes of the labium of two* joints. Males often with auricles on 2, and the anal margin of the hind wings excavated.

Subfamily 3. Gomphinæ.—Head transversely elongated, eyes separated. Abdomen without lateral carinæ. Females without genital valves (except in the legion *Petalura*).

Subfamily 4. Cordulegasterinæ.—Head transversely elongated, eyes a little separated, or meeting in a single point dorsally. Abdomen without lateral carinæ. Females without genital valves.

Subfamily 5. Aeschninæ.—Head globose, eyes meeting on the top of the head for a space. Abdomen with lateral carinæ. Females with genital valves.

FAMILY 3. LIBELLULIDÆ.—Triangle of front wings with its long axis at right angles to the length of the wing, triangle of hind wings with its long axis coinciding with that of the wing. Antecubitals of first and second series mostly coincident. No postcubitals in the nodal end of the second series. Lateral lobes of the labium of one† joint. Head globose, eyes meeting on the top of the head. Abdomen with lateral carinæ. Females without genital valves.

* *I. e. ll* and *tp* of fig. 7, pl. II.

† *I. e. ll* of fig. 7, pl. II.

Subfamily 6. Cordulinæ.—Hind margin of eyes produced as a small tubercle. Usually a small bundle of fine hairs on the distal anterior surface of the first femora. Males with auricles on 2, anal margin of hind wings excavated, distal end of first tibiæ with an inferior carina.

Subfamily 7. Libellulinæ.—Hind margin of eyes not produced as a small tubercle, or with a mere trace of such. Males without auricles on 2, anal margin of hind wings not excavated.

CHARACTERS OF THE GENERA (imagos only).

Subfamily 1. CALOPTERYGINÆ.

Legion Calopteryx Selys.—Sectors of the arculus arising from below its middle, antecubitals of first and second series nearly equal in number, quadrilateral as long as the basilar space, pterostigma absent or of one to several cells. Epistoma not projecting as much as the length of the eyes.

Basilar space free, arculus broken, an inferior branch to the lower sector of the triangle, quadrilateral straight; ♂ superior appendages forcipated, no pterostigma; ♀ pterostigma absent or present.....1. **Calopteryx**.

Basilar space cross-veined, arculus not broken, no inferior branch to the lower sector of the triangle; ♂ wings with a basal red spot, cells of postcostal space on front wings irregular..... 2. **Hæterina**.

Subfamily 2. AGRIONINÆ.

I. Legion Lestes Selys.—Median and subnodal sectors parting from the principal sector much nearer the arculus than the nodus; ♂ superior appendages forcipated.

Nodal sector parting from the principal 3-5 cells after the nodus; supplementary sectors between the subnodal and the median, and the median and the short and other sectors; hind margin of the prothorax rounded, entire; pterostigma 3-4 times as long as broad3. **Lestes**.

II. Legion Agrion Selys.—Median and subnodal sectors parting from the principal near the nodus; quadrilateral trapezoidal, upper side shorter than the lower, lower external angle acute; no supplementary sectors except the ultra-nodal; lower sector of the triangle extending to the hind margin of the wing; pterostigma of but one cell.

Hairs of the tibiæ about twice as long as the intervals between them; a single row of postcostal cells; arculus complete, lying in the prolongation of the second antecubital; tarsal nails toothed, tooth shorter than the nail proper.....4. **Argia**.

Hairs of the tibiæ never twice as long as, but generally shorter than, the intervals between them; otherwise as in *Argia*. (In all the following genera the postcostal vein separates from the hind margin in front of the basal postcostal cross-vein.)

A. ♀ with no apical ventral spine on 8. Pterostigma similar on front and hind wings.

No pale postocular spots; color brown and blue or yellow.

5. **Erythromma**.

Pale postocular spots or line present; color metallic, similar in ♂ and ♀; abdomen extremely slender.....6. **Nehalennia**.

B. ♀ with an apical ventral spine on 8.

No pale postocular spots.

Pterostigma similar on front and hind wings; color red; ♂ with no bifid process on dorsum of 10.....7. **Amphiagrion.**

A pale (postocular) spot behind each eye.

Pterostigma of ♂ similar in color on front and hind wings, no dorsal bifid process on 10 (except in *E. exculsans* ♂). Nodal sector (♂ ♀) arising near 5th postcubital on front wings, 4th on hind wings, or more remote.....8. **Enallagma.**

Pterostigma of ♂ dissimilar in color on front and hind wings, 10 with a dorsal process (♂) bifid at its apex.

Pterostigma of ♂ touching the costa on front wings, darker than on hind wings. Front wings (♂ ♀) with usually more than 7 postcubitals. (The species included in this catalogue have the nodal sector usually arising at the 4th postcubital on the front wings, at the 3rd on the hind wings; this aids in distinguishing from *Enallagma*.)

9. **Ischnura.**

Pterostigma of ♂ not touching the costa on the front wings. Front wings (♂ ♀) with usually, but not always, less than 7 postcubitals. Nodal sector arising not farther than the 4th postcubital.

10. **Anomalagrion.**

Subfamily 3, GOMPHINÆ.

I. Median labial lobe bifid.

Legion Petalura Selys.*—Basilar space free; triangles of front wings crossed; membranule very small; ♀ with genital valves.

Triangle of front wings with the upper side longer than the inner, the outer longest; hair-like termination of antennæ jointed; ♂ superior appendages not more than twice as wide in front of apex as at base, inf. app. more than half as wide at base as long.....11. **Tachopteryx.**

II. Median labial lobe entire; basilar space free. No genital valves.

Legion Gomphoides Selys.—All or some of the triangles crossed; membranule wanting, or very small.

Feet long, hind femora reaching backwards to base of 3; discoidal triangles crossed, internals and supratrangular spaces free; abdomen blackish, with a dorsal yellow stripe.....12. **Hagenius.**

Legion Gomphus Selys.—All the triangles and the supratrangular spaces free; membranule wanting, or very small.

♂. Inferior appendage bifid, its branches almost contiguous. 10 considerably shorter than 9. ♂ inf. app. bifid in its apical half, branches straight, upcurved at apex. ♀. Vulvar lamina nearly as long as 9 (except in the European *O. serpentinus*), divided into two narrow, quite long, parallel, almost contiguous branches, pointed at their apices.

13. **Ophiogomphus.**

* It may hereafter be necessary to regard this as representing a distinct subfamily—the Petalurinae.

♂. Inferior appendage bifid, its branches divergent; superior appendages at most but little longer than 10, their divergence but little different in width from that of the branches of the inferior; lateral margins of 8 not dilated into membranous appendages; 2nd joint of penis usually with a tooth; a salient anal angle. ♀. Vulvar lamina at most hardly longer than half of 9. 10 considerably shorter than 9 (♂ ♀).

Third femora moderate (when extended backwards reaching no farther than the middle of 2). all the spines short, numerous.....14. **Gomphus**.

Third femora long (when extended backwards reaching to base of 3), with an antero-inferior row of 5-7 spines which are considerably longer than the more numerous short spines15. **Dromogomphus**.

Subfamily 4. CORDULEGASTERINÆ.

Frons not elevated as high as the occiput, wings not spotted. ♂ with auricles on 2.....16. **Cordulegaster**.

Subfamily 5. AESCHNINÆ.

I. Upper piece of the arculus equal to or longer than the lower piece, its upper sector arising a short distance above the lower sector, being separated from the latter by a distance $\frac{1}{2}$ - $\frac{3}{4}$ of that separating the upper sector from the median nerve. ♂ hind wings with anal triangle, distinct anal angle, auricles on 2.

Supplementary sector between the subnodal and median sectors curved at its middle *towards* the former or its posterior fork to be almost parallel, and separated by 1-2 (rarely 3) rows of cells.

Subnodal sector forked at its extremity.

Subcostal vein not prolonged beyond the nodus; basilar space free; pterostigma long, narrow; median space with at least 2 cross-veins in addition to that forming the internal triangle; two rows of cells between subnodal sector and the supplementary sector next below it. ♂ anal triangle of 3 cells.....17. **Epieschna**.

Subnodal sector not forked or branched.

Basilar and supra-triangular spaces cross-veined...18. **Fonscolombia**.

Basilar and supra-triangular spaces free.....19. **Gomphæschna**.

Supplementary sector between the subnodal and median sectors curved at its middle *away* from the former or its posterior branch, with 3-7 rows of cells between them at that place.

Subnodal sector forked or with several small branches; suture between the eyes short or moderately long (*i. e.* not longer than combined length of vertex and frons measured on mid-dorsal line); subcosta not prolonged beyond the nodus.....20 **Aeschna**.

II. Upper piece of the arculus shorter than the lower piece, its upper sector arising close to the median vein (midway between the latter and the lower sector). ♂ hind wings without anal triangle, anal angle rounded off, no auricles on 2.

External branch of lower sector of the triangle in hind wings approaching the upper sector for its apical half, being parallel to it and separated by one row of cells; 4 (♂) or 5 (♀)--10 usually with a supplementary lateral carina above the usual one.....21. **Anax**.

Subfamily 6. CORDULINÆ.

- I. *Legion Macromia* Selys.—Supra-triangular space crossed; triangle of the front wings regular, with the anterior side unbroken; membranule large; sectors of the arculus more or less united at their origins.

Basilar space free; inner side of triangle of hind wings farther from the base than the arculus; two posttriangular rows (rarely one) on the front wings.

Eyes touching for hardly more than a point; occiput quite prominent on the dorsal surface of the head and considerably larger than the vertex; distance from nodus to pterostigma on costal border of front wings more than half as long as from base to nodus; all triangles free.

22. **Didymops.**

Eyes touching for a short distance; occiput inconspicuous and much smaller than the vertex; triangles crossed or free.....23. **Macromia.**

- II. *Legion Cordulia* Selys.—Supratrangular space free; sectors of the arculus almost always separate at their origins.

Triangle of the front wings regular, anterior side unbroken; membranule moderate or large.

Wings with dark spots at base, apex and frequently at nodus; triangle of hind wings crossed; abdomen slightly depressed, longer than hind wings; one cross-vein immediately beneath the pterostigma. ♀. Vulvar lamina almost as long as 9, deeply bilobed.....24. **Epicordulia.**

Hind wings with some black at base; triangle of hind wings free; abdomen depressed, as long as, or a little shorter than hind wings; one cross-vein immediately beneath the pterostigma. ♀. Vulvar lamina at least as long as 9, deeply bilobed.....25. **Tetragoneuria.**

Wings with small dark spots at base and along front margin; triangle of hind wings crossed or free; abdomen usually longer than hind wings; two cross-veins immediately beneath the pterostigma. ♀. Vulvar lamina not more than half as long as 9, divided into two divaricate, triangular plates.....26. **Neurocordulia.**

Wings without dark spots; triangle of hind wings crossed or free; colors metallic.....27. **Somatochlora.**

Subfamily 7. LIBELLULINÆ.

- I. Lower angle of triangle of front wings placed as far beyond the level of the outer angle of the triangle of the hind wings, as the latter triangle is long; eyes connected for a space at most not much greater than the thickness of the vertex; no antenodal concavity on front margin of wings.

Ab. seg. 3 and 4 with two additional transverse carinæ, 5 with one; nodal sector waved.....28. **Pantala.**

Ab. seg. 3 and 4 with one additional transverse carina, 5 with none; sectors of the arculus arising from a common stalk; triangle of front wings crossed, nodal sector not waved or broken.....29. **Tramea.**

- II. Lower angle of triangle of front wings placed on a level with the outer angle of the triangle of the hind wings, or only a little beyond it; tarsal nails toothed; otherwise as in (I).

Hind lobe of the prothorax with its middle portion produced upwards and backwards and *narrower* than the other lobes, its hind margin usually entire; triangle not densely reticulated.

Sectors of the arculus in the front wings not arising by a common stalk; nodal sector distinctly waved in its middle: front wings with supra-triangulars, 11 or more antecubitals, 8 or more postcubitals.

♂ with no ventral hooks on 1; ♀ with third tibiæ at least a little longer than third femora.....30. **Libellula.**

♂ with a pair of ventral hooks on 1; ♀ with third tibiæ as long as third femora31. **Plathemis.**

Sectors of the arculus in front wings arising by a common stalk.

Anterior side of triangle of front wings not broken to form a trapezium; last antenodal on front wings not continued to the median vein; lower sector of the triangle in hind wings arising from the hind angle, the upper from the outer side of the triangle.

32. **Micrathyrina.**

Anterior side of triangle of front wings broken to form a trapezium, the outer broken piece shorter than the inner; no supratrangulars; hind wings with no internal triangle.....33. **Nannothemis.**

Hind lobe of the prothorax erect, *wider* than the other lobes, its hind margin usually bilobed.

Both sectors of the triangle in the hind wings arising from its hind angle; nodal sector not waved in its middle.

Abdomen at least fairly slender, compressed at base; if depressed it is so in a special widening of the anteapical segments; hamule of ♂ bifid.

Pterostigma at least four times as long as wide; vertex truncated at tip; front wings with 7-10 antecubitals, the last one variable; hind wings with at least two dark brown basal patches, one in front of the other, and separated by a clear yellow space, the front one reaching forwards to the submedian vein; 3-7 black with a mid-dorsal, maculate, yellow band.....34. **Celithemis.**

Pterostigma at most twice as long as wide; vertex rounded at tip; front wings with 6-8 antecubitals, the last one usually continued to the median vein; hind wings with a small basal black patch reaching forwards to the submedian vein; frons and nasus white; abdomen not widened at base and before apex.35 **Leucorhinia.**

Pterostigma variable; vertex truncated at tip; front wings with 7-10 antecubitals, the last one rarely continued to the median vein; abdomen and hind wings without the characteristic patterns of coloring described for *Celithemis* and *Leucorhinia*.....36. **Diplax.**

Abdomen at least fairly stout, depressed, tapering to apex; hamule of ♂ not bifid; front wings with last antecubital not continued to the median vein; 4 with an additional transverse carina.

37. **Perithemis.**

Lower sector of the triangle in the hind wings arising from its hind angle, the upper from its outer side; sectors of the arculus in the front wings arising by a common stalk; hamule of ♂ bifid.

Last antecubital of front wings usually not continued to the median vein ; third tibiæ with the spines of the antero-inferior row few (5-7) and stout ; abdomen stout, hardly as long as the hind wings.

38. **Mesothemis.**

Last antecubital on front wings continued to the median vein ; vertex truncated at tip ; front wings with not more than 7 antecubitals, triangle crossed, 3 rows of posttriangular cells..39. **Pachydiplax.**

SYSTEMATIC CHARACTERS OF NYMPHS.*

I. Three caudal tracheal-gills (Zygoptera).

Legion Calopteryx.—Basal joint of antennæ thick, more than twice as long as the other six together. Median lobe of labium bifid.

Front edge of median lobe of labium bifid to form a lozenge-shaped interval between, which extends basally beyond the level of the attachment of the lateral lobes. Rear of head with a tooth each side. Median caudal gill flat, shorter than the other two...1. **Calopteryx** (see fig. 8, pl. II.)

Front margin of median lobe of labium bifid only as far basally as the level of the attachment of the lateral lobes. Abdominal segments with a lateral membrane whose margins are denticulated. Median caudal gill a little swollen at apex.....2. **Hæterina.**

Subfamily Agrioninæ.—Basal joint of antennæ hardly longer than thick, much shorter than the second or the third.

Lateral lobes of labium (excluding the terminal palp) deeply bilobed, median lobe barely bifid.....*Legion Lestes.*

Lateral lobes of labium (excluding the terminal palp) not deeply bilobed, median lobe entire.....*Legion Agrion.*

The veins on the wing-covers will assist in determining between these two legions as in the imagos.

II. No caudal tracheal-gills (Anisoptera).

Subfamily Gomphinæ.—Antennæ 4-jointed, fourth joint rudimentary ; first and second tarsi 2-jointed ; labium flat, not covering the labrum or frons when closed.

First legs less distant from each other at base than are the second legs. Abdomen much less than twice as long as broad, very flat, almost circular when viewed from above. Third joint of antennæ large, flat, circular.

12. **Hagenius.**

First legs as distant from each other at base as are the second legs. Abdomen at least twice as long as broad.

Middle third of front margin of median lobe of labium produced in a very short rounded lobe with pavement teeth and a comb of flat scales.

13. **Ophiogomphus.**

Middle third of the same straight, or nearly so.....14. **Gomphus.**

Subfamily Cordulegasterinæ.—Antennæ 7-jointed ; all tarsi 3-jointed ; labium spoon-shaped, covering labrum and frons when closed, teeth on the opposed margin of the lateral lobes long, interlocking when closed so as to form a distinctly zigzag line of union. Abdomen two to three times as long as broad.

* Based on Cabot (50), Hagen (52, 53) and Garman "A Preliminary Report on the Animals of the Waters of the Mississippi Bottoms," etc. Springfield, Ill., State Printer, 1889.

- Characters of the subfamily.....16. **Cordulegaster.**
Subfamily Aeschninæ.—Antennæ 6-7 jointed; tarsi 3-jointed; labium flat, not covering labrum or frons when closed.
 Antennæ 6-jointed.
 Head broader than long; a lateral spine on 4-9, middle and inferior appendages of equal length*.....17. **Epiaeschna.**
 Antennæ 7-jointed. Head broader than long.
 Hind dorsal margin of 9 concave.
 A lateral spine on 4-9, middle appendage sharply pointed.
 18. **Fonscolombia.**†
 A lateral spine on 5-9, middle appendage bifid at tip.
 19. **Gomphaeschna.**†
 Hind dorsal margin of 9 straight.
 Eyes more prominent at the fore corner; labium at rest extending backwards to the second legs; a lateral spine on 4, 5 or 6-9. ♂ projection conical. ♀ valves reaching apex of 9.....20. **Aeschna.**
 Eyes more prominent in the middle; labium at rest extending backwards beyond second legs; a lateral spine on 7-9; middle appendage notched at tip, laterals half as long. ♂ projection cut at tip. ♀ valves shorter than 921. **Anax.**
Family Libellulidæ.—Antennæ 7-jointed; tarsi 3-jointed; labium spoon-shaped, covering labrum and frons when closed. Some Libelluline nymphs closely resemble those of the Cordulegasterinæ (*q. v.*), but may be distinguished by the teeth on the opposed margin of the lateral labial lobes being so short as to form an almost straight line of union when closed. Characters for separating Corduline from Libelluline nymphs are as yet unknown, as the latter subfamily has not been monographed.‡
Subfamily Cordulinæ :
 An erect pyramidal horn on the front of the head.
 No dorsal hook on 10; lateral spines on 9 reaching as far as level of tips of appendages.....22. **Didymops.**
 At least a small dorsal hook on 10; lateral spines on 9 much shorter than in *Didymops*.....23. **Macromia.**

* A clerical error in Part I has caused some confusion in regard to the appendages of Anisopterous nymphs. For "lateral" should be read "inferior" on page 196, line 25, p. 198, line 5 from bottom, and p. 199, line 3 from top. The denial of the homology of the inferior appendages of the males of the Zygoptera and Anisoptera (p. 199) refers, of course, to imagos only. Of the five appendages which terminate the abdomen of older Anisopterous nymphs, two are ventral—the *inferiors*, one is mid-dorsal (the *middle*) and on either side of it is a *lateral*, corresponding to a superior appendage of the imago.

† The identification of these is as yet doubtful (Cabot).

‡ As this is going through the press Dr. Karsch has published a paper on "Die Insecten der Berlandschaft Adeli" (West Africa) (Berl. Ent. Zeit. xxxviii, pp. 1-226, July, 1893) in which he gives characters for the separation of Corduline from Libelluline nymphs (p. 42). These characters will not serve for American species, and his characters for those of the "Calopterygidæ" are only those of the legious Calopteryx and Libellago (?).

No erect pyramidal horn on the front of the head.

A tubercle on either side of the top of the head; 10 very short, a dorsal hook on 3-9, a sharp lateral spine on 8-9, those of 9 exceeding the appendages.....24. **Epicordulia**.

No such tubercles.

Lateral spines of 8 very short, of 9 long, sharp, divergent, much longer than the appendages..25. **Tetragoneuria** (group of *cynosura*).

Lateral spines of 8-9 flat, sharp, incurved; of 9 not longer than the appendages.....27. **Somatochlora** (group of *libera*).

Subfamily Libellulinæ:

Middle (dorsal) terminal appendage a little longer than the inferiors (ventrals), all spinous. Teeth on opposed margin of lateral labial lobes flat, not interlocking, 8 and 9 with a long, sharp, incurved lateral spine.....28. **Pantala**.

Middle (dorsal) terminal appendage shorter than the inferiors, laterals without spines. Teeth on opposed margin of labial lobes much shorter than in *Pantala*, interlocking in a nearly straight line; otherwise as in *Pantala*.....29. **Tramea**.

The nymphs of but a small proportion of the species are known, so that no attempt is made in this paper to define their specific characters.

LIST AND CHARACTERS OF THE SPECIES.

[N. B.—The following explanations, in addition to those contained in the preface, are required for the proper understanding of the subsequent text. Much greater importance is attached to structural than to color differences; what are regarded as the important specific characters are indicated by *italics*. Although teneral colors (see p. 203) are often mentioned, the colors usually described are those of the adult insect, and allowance must be made for such age-differences in identifying specimens. The wings are to be understood as being colorless, unless otherwise stated. The abdominal segments are denoted by the numerals 1 to 10. Measurements are always expressed in millimetres, and the length of the abdomen always includes the terminal appendages. Names of collectors have usually been cited at the end of the list of localities for each species in such cases where their labors have extended the known areas of distribution beyond those already published by Hagen (37), de Selys, Banks (38) and others. Abbreviations employed are Sup. app., superior appendages. Inf. app. inferior appendages. Abd., abdomen. H. w., hind wing. Phila., Philadelphia. Del. Co., Pa., Delaware County, Pennsylvania. N. J., New Jersey. Twp., Township. A. E. S., W. I., C., collections of the American Entomological Society, Wagner Free Institute of Science and of P. P. Calvert, respectively.]

Subfamily 1. CALOPTERYGINÆ.

1. **Calopteryx** Leach.

(*Calepteryx*) Leach, Edinb. Encyc. ix. p. 137, 1815. Amer. Edit. viii, pt. ii. p. 726, 1816. Selys, Mon. Calopt. p. 22, 1854.

1. Calopteryx maculata Beauv.

Agrion m. Beauvois, Ins. Afr. Amer. p. 85, Neur. pl. 7, fig. 3, 1805. *C. m.* Hagen, Psyche v, p. 249, 1889.

Metallic blue or green; labium, two lateral thoracic stripes, pectus, venter of 1-7 or 8, black. Hind margin of wings decidedly convex.

♂. Wings *velvety black* (gray or brown--teneral), no pterostigma. Venter of 8-10 whitish. Sup. app. with outer margin denticulated, apical half wider, bent inwards and downwards. apex obtuse. Inf. app. one-fourth shorter, extreme apex acute, bent inwards.

♀. Wings smoky, apical fourth sometimes darker; *pterostigma* white, of 6-12 cells; veins metallic; 8 or 9-10 with a mid-dorsal longitudinal line and a spot each side, whitish or yellowish.

Abd. ♂ 34-40, ♀ 30-41.5. Hind w. ♂ 27-27.5, ♀ 29-34.5.

Common around Phila., along the banks of narrow streams, May 24—Aug. 17; ovipositing June 28, July 6.

Quebec—Florida, west to Kansas and Texas.

2. *Calopteryx dimidiata* Burm. race *apicalis* Burm.

C. a. Burmeister, Handb. Ent. ii, p. 827, 1839. Hagen, Psyche v, p. 246, 1889.

Metallic green or blue; labium, head below, thoracic sutures, feet, abdominal venter, black. A *sharp tubercle* on each side of rear of head. Wings narrow hind and front margins parallel for a part of their length.

♂. Wings with *apical sixth black*, its inner border straight; no pterostigma. Sup. app. similar to *maculata*.

♀. Wings hyaline; *pterostigma* absent, or very small and white, of 2-3 cells.

Abd. ♂ 35-37, ♀ 31-32. H. w. ♂ 27, ♀ 29.

Phila., 2 ♂ 1 ♀ (Burmeister), 1 ♂, 1 ♀ (Uhler)—Hag. *l. c.*

Massachusetts, New York, Delaware (Beutenmüller, A. E. S.)

2. *Heterina* Hagen.

Hagen, Syn. Calopt. p. 30, 1853. Selys, Mon. Calopt. p. 96, 1854.

3. *Heterina americana* Fabr.

Agrion a. Fabricius, Ent. Syst. Supp. p. 287, 1798. *H. a.* Walsh, Proc. Ent. Soc. Phila. ii, pp. 211, 267, 1863. *Agrion basalis* Say, Harris Ins. Inj. Veg. (Flint's edit.) pl. 1, fig. 2, 1862.

Head and thorax coppery red (♂) or metallic green (♀), or these sometimes reversed. Thorax with a humeral and two lateral stripes, pectus, yellow. Abdomen metallic green, an interrupted, basal, yellow ring on 3-7. *Tips* of wings *unspotted*; *pterostigma* very small, yellow. *Tibix* *superiorly pale*.

♀. Basal fifth or sixth (except at front border of front wings) bright red, sometimes replaced by reddish brown on hind wings. *Sup. app.* forecipated, inner margin near middle with two tubercles, of which the more basal is the larger, whose sides are convergent (the apical side longer) whose tip is obtusely rounded, and whose surface bears no smaller tubercles; the other (distal) tubercle has the basal side longer, its tip rounded; apex of sup. app. obtuse. Inf. app. reaching first tubercle of superiors, nearly straight, narrowing to the truncated apex.

♀. Base and front margin of wings pale yellowish brown. Mid-dorsal thoracic carina sometimes yellow; 1-10 with a narrow, interrupted, mid-dorsal, yellow line.

Abd. ♂ 34-37, ♀ 31. Hind w. ♂ 25-30, ♀ 28.

Crum and Ridley Creeks, Del. Co., Pa., and elsewhere near Phila., Aug. 11—Sept. 23.

Maine to Maryland, west to Wisconsin and Missouri.

4. *Heterina tricolor* Burm.

Calopteryx t. Burmeister, Handb. Ent. ii, p. 827, 1839. *H. t.* Selys, Mon. Calopt. p. 136, pl. 12, fig. 5, 1854.

Blackish brown. Thorax with a humeral and two lateral stripes, pectus, yellow. *Tibiæ black.*

♂. *Extreme tips* of all the wings *brown*; basal sixth of front wings, except on front margin, bright red, with *no* adjoining brown; basal fifth of hind wings brown. *Pterostigma black.* *Sup. app.* longer than 10, forcipated, inner edge with a basal tubercle and a median dilatation, whose edge is straight or convex, and which ends abruptly, nearly at right angles. *Inf. app.* half as long, straight, apices upcurved.

♀ (not seen by the writer). Wings not spotted, base somewhat yellowish. *Pterostigma yellow.*

Abd. ♂ 40–42, ♀ 37. Hind w. ♂ 29–30, ♀ 31.

Philadelphia—Hagen (37).

Pennsylvania, Georgia, Texas (A. E. S.).

Subfamily 2. AGRIONINÆ.

3. *Lestes* Leach.

Leach, Edinb. Encyc. ix, p. 137, 1815. Amer. Edit. viii, pt. II, p. 726, 1816. Selys, Bull. Ac. Belg. (2) xiii, p. 295, 1862.

A. ♂. *Inf. app.* not longer than half the *sup. app.*

Lestes eurina Say (Pl. III, fig. 14).

L. e. Say, Journ. Ac. Phila. viii, p. 36, 1839. Walsh, Proc. Ac. Phila., 1862, p. 385. Seudder, Psyche vi, p. 66, 1891.

Dark metallic green; lips pale green, blue, or yellow; mid-dorsal carina and humeral suture black, sides yellow inferiorly, with a variable blackish spot or band on the second lateral suture. *Wings pale yellowish.*

♂. *Sup. app.* on inner side with an acute basal tooth and a truncate median tooth, whose edge is denticulated; apices somewhat thickened. *Inf. app.* one-third as long, straight, apex blunt, not dilated.

♀. Mid-dorsal thoracic carina yellow.

Abd. ♂ 35.5–41, ♀ 34. Hind w. ♂ 25–29, ♀ 28.

Massachusetts (Say, Babcock—A. E. S., C.), Illinois (Walsh).

Dobb's Ferry, N. Y., July 7, 10, 23, by G. D. W. Williamson (C.).

Lestes congener Hagen (Pl. III, fig. 15).

L. c. Hagen, Syn. Neur. N. A., p. 67, 1861. Selys, Bull. Ac. Belg. (2) xiii, p. 316, 1862.

Blackish brown; lips, sides of thorax inferiorly, usually a narrow humeral stripe, sometimes rear of head and mid-dorsal carina—yellow. Two oblique black marks behind third coxæ; a black line on second lateral suture.

♂. *Sup. app.* on inner side with a short, acute, basal tooth, followed by a small,

straight dilatation, somewhat denticulated, ending by an obtuse angle. *Inf. app.* reaching to the middle of the dilatation, with apices curved inwards and upwards, blunt, not dilated.

♀. Abdomen with a narrow, yellow, mid-dorsal line.

Abd. ♂ 28-29, ♀ 25-27. Hind w. ♂ 18.5-21, ♀ 20-22.

New York, Delaware, Yellowstone, Colorado, Nevada (Hillman).

B. ♂. *Inf. app.* longer than half of, but not longer than, *sup. app.* Rear of the head (♂ ♀) blackish.

a. ♂. *Inf. app.* s-shaped. ♀ with a yellow band from eye to eye across rear of head.

Lestes unguiculata Hagen (Pl. III, fig. 16).

L. u. Hagen, Syn. Neur. N. A., p. 70, 1861. Selys, Bull. Ac. Belg. (2) xiii, p. 299, 1862.

Blackish brown; lips, mid-dorsal thoracic carina, a humeral stripe (usually, narrower in ♂ than ♀), and the sides inferiorly, yellow. Frequently a broad oblique, blackish band near second lateral suture. Abdom. dorsum metallic brown or green, 3-7 with an interrupted, basal, yellow ring. Pterostigma brown, the vein at each end white.

♂. *Sup. app.* on inner side with a *short, acute, basal tooth*, followed by a *dilatation whose edge is first convex, then concave*, and more or less denticulated. *Inf. app.* somewhat s-shaped, curving from base to apex, outwards, inwards and outwards. Much of adult ♂ pruinose. Teneral males also show the postcephalic band of the ♀.

♀. Humeral stripe wider below.

Abd. ♂ 25-31.5, ♀ 22.5-31.5. Hind w. ♂ 17-21.5, ♀ 17.5-25.

♂ ♀, Pennsylvania, June 16, by S. F. Aaron (A. E. S., C.).

Quebec to Pennsylvania, and across the continent to California.

(Sheraton, J. P. Moore, Hitchings, Harvey, Truman, Cheney, Hillman,—A. E. S., C.)

b, ♂. *Inf. app.* straight, or nearly so. ♀ with no yellow postcephalic band.

Lestes uncata Kirby (Pl. III, fig. 18).

L. u. Kirby, Cat. Odon. p. 160, 1890. *L. forcipata* Hagen, Syn. Neur. N. A., p. 71, 1861. *L. hamata* Selys, Bull. Ac. Belg. (2) xiii, p. 300, 1862.

Metallic green. Lips, a humeral stripe (occasional in ♂) and sides of thorax inferiorly, yellow.

♂. *Sup. app.* on inner side with *two acute teeth*, edge between them denticulated. *Inf. app.* reaching as far as the second tooth, *almost straight, apices widened on the inner side.*

♀. Mid dorsal thoracic carina yellow; humeral stripe *uniformly narrow.*

Abd. ♂ 26-32, ♀ 23.5-29. H. w. ♂ 19-22, ♀ 19-24.

Nova Scotia, Maine, New Hampshire, Massachusetts, District of Columbia, Georgia, Ontario, Illinois, Wisconsin, South Dakota, California (Miss Wadsworth, Mrs. Slosson, Sheraton, Calvert—A. E. S., C., Mich. Agric. College).

Lestes disjuncta Selys (Pl. III, fig. 19).

L. d. Selys Bull. Ac. Belg. (2) xiii, p. 302. 1862.

Blackish brown. Lips, sometimes mid-dorsal thoracic carina, a humeral stripe and sides of thorax inferiorly, yellow or pale green. 3-6 with an interrupted, transverse, basal, yellow ring.

♂. Sup. app. on inner side with *two acute nearly equal teeth*, edge between them denticulated. Inf. app. exceeding the second tooth, almost straight, *apices not widened*. Old ♂ with an oblique black band on second lateral suture, prothorax, base and apex of abdomen pruinose.

♀. Humeral stripe wider than in ♂, somewhat wider below.

Abd. ♂ 27-30.5, ♀ 26-29. H. w. ♂ 18-20, ♀ 20-21.5.

Nova Scotia, Maine, New Hampshire, New York, Illinois, Colorado, Yellowstone (Mrs. Slosson, J. P. Moore, Calvert—A. E. S., C.).

5. Lestes forcipata Rambur (Pl. III, fig. 20).

L. f. Rambur, Nev. p. 246, 1842. Selys, Bull. Ac. Belg. (2) xiii, p. 303, 1862.

L. hamata Hagen, Syn. Neur. N. A., p. 70, 1861.

Blackish brown. Lips, mid-dorsal thoracic carina, humeral stripe (broader below) and sides of thorax inferiorly, yellow.

♂. Sup. app. on inner side with *two teeth, basal one larger, acute*, edge between straight, denticulated. Inf. app. exceeding second tooth, almost straight, *apices a little dilated*. Old ♂ with an oblique black band on second lateral suture, or with sides of thorax, base and apex of abdomen pruinose.

♀. Humeral stripe *distinctly wider* below.

Abd. ♂ 30-35, ♀ 28-34. H. w. ♂ 19-24, ♀ 22-25.

Ridley Twp., Del. Co., Pa., May 30—July 31; transforming July 21. One ♂, N. J., May 8; 2 ♂ 1 ♀ Pa. May 19-27 (A. E. S.).

Massachusetts to Florida, Wisconsin, Illinois, Texas, Colorado (Hitchings, Richardson—A. E. S., C.).

6. Lestes rectangularis Say (Pl. III, fig. 21).

L. r. Say, Journ. Ac. Phila. viii, p. 34, 1839. Selys, Bull. Ac. Belg. (2) xiii, p. 306, 1862.

Blackish brown. Lips, mid-dorsal thoracic carina, humeral stripe (wider below), sides of thorax inferiorly green or yellow. 9 sometimes with a dorsal pruinose spot.

♂. Sup. app. on inner side with *two acute teeth, basal one shorter and less acute*, edge between denticulated. Inf. app. reaching or exceeding the second tooth, almost straight, *apices bent down, not dilated*.

♀. Humeral stripe *wider below*. De Selys *l. c.*, says that the ♀ *rectangularis* may be distinguished from the other species by the genital valves not being denticulated on the free edge, but this is very doubtful.

Abd. ♂ 33-42, ♀ 31-32.5. H. w. ♂ 18.5-22, ♀ 22-23.5.

Small streams around Phila., July 14—Sept. 14.

Maine to Georgia, west to Minnesota (Miss Wadsworth, Mrs. Slosson, Jones, Calvert—A. E. S., C., Mich. Ag. Coll.).

Lestes vigilax Selys (Pl. III, fig. 17).

L. v. Selys, Bull. Ac. Belg. (2) xiii, p. 306, 1862.

♂. *Metallic green*. Lips blue or yellow. Thorax with mid-dorsal carina, a narrow humeral stripe and sides inferiorly, yellow. Posterior abdominal segments blackish. Sup. app. on inner side with a *basal, moderately acute tooth followed by two round tubercles*. Inf. app. *very slender*, exceeding the second tubercle, *apices not dilated*. Old ♂ with rear of head, sides of thorax, 9-10, pruinose.

♀. Unknown.

Abd. ♂ 34.5-38. H. w. ♂ 21-25.

One ♂, Pa. (A. E. S.) Morris Co., New Jersey, July 10, by C. W. Johnson (W. I., C.). Massachusetts (Hitchings).

C. ♂. Inf. app. longer than sup. app. Rear of the head (♂ ♀) yellow.

7. Lestes inequalis Walsh (Pl. III, fig. 24).

L. i. Walsh, Proc. Ac. Phila. 1862, p. 385.

Metallic green. Lips pale brown or blue. Mid-dorsal thoracic carina and a humeral line yellow or black. Sides of thorax inferiorly yellow.

♂. Sup. app. on inner side with an *acute basal tooth, followed by a somewhat convex denticulated edge, and a rather flat, rounded tubercle*. Inf. app. *a little longer, very slender*, straight, apices curved upwards and inwards, *not dilated*.

♀. Humeral stripe wider below, 9 sometimes with two dorsal yellow spots. Old ♀ with rear of head, 9-10, pruinose.

Abd. ♂ 36-42, ♀ 35-40. H. w. ♂ 25-26.5, ♀ 25-27.

Ditches, Tinicum Is., Pa., June 24, July 22, by P. P. Calvert (C.) ; not abundant.

Maine, New Hampshire, New Jersey, Illinois (Harvey, Mrs. Slosson, C. W. Johnson).

4. Argia Rambur.

Rambur, Név. p. 254, 1842. Selys, Bull. Ac. Belg. (2) xx, p. 382, 1865.

A. More than one cell lying immediately beneath the pterostigma.

8. Argia putrida Hagen.

Agrion p. Hagen, Syn. Neur. N. A., p. 96, 1861. *Argia p.* Selys, Bull. Ac. Belg. (2) xx, p. 385, 1865.

Rear of the head *blackish*.

♂. Head and thorax clay-colored. Thorax with a mid-dorsal band, a humeral line and a post-humeral stripe confluent below, and a line on the second lateral suture, black. Abdomen black, a pale, transverse, basal ring on 3-7; sometimes a pale dorsal spot on 9. Old ♂ mostly pruinose. Hind margin of 10 excised, sides of excision thickened, elevated and produced backwards as a small process on either side overhanging, but shorter than, the sup. app. Sup. app. one-third as long as 10, blunt. Inf. app. two to three times thicker, obtuse, usually longer, apex entire.

♀. Head and thorax pale green. Thorax with mid-dorsal carina, sometimes the lateral sutures, or even a mid-dorsal band, black. Abdomen green, an interrupted black stripe each side.

Abd. ♂ 30-37, ♀ 29-37. H. w. ♂ 23-26.5, ♀ 24-28.5.

Near Phila., June 24, 30, by S. F. Aaron (A. E. S.); abundant; in copula June 30. Little Crum Creek, Ridley Twp., Del. Co., Pa., July 6, by P. P. Calvert (C).

Quebec to Florida; Texas, Illinois, Wisconsin (Provancher, Miss Wadsworth, Harvey, Hitchings, Mrs. Slosson, Johnson—A. E. S., C.)

B. Only one cell lying immediately beneath the pterostigma.

a. Pale colors predominating on thoracic dorsum.

9. *Argia violacea* Hagen.

Agrion v. Hagen, Syn. Neur. N. A., p. 90, 1861. *Argia v.* Selys, Bull. Ac. Belg. (2) xx, p. 404, 1865.

Rear of the head *yellowish*. Pterostigma *brown*. Thorax with a mid-dorsal and a *humeral stripe*, and a line on second lateral suture, black. Vertex black.

♂. Violet, including post-ocular spots; two apical spots on 2-6, and the most of 7, black; 8-10 *blue*. Hind margin of 10 excised as in *putrida*. Sup. app. one-third as long as 10, blunt. Inf. app. twice as long and as thick, directed upwards; extreme apex *slightly notched* in profile.

♀. Brown, or brownish green; a black stripe each side of 2-9, widest on 7.

Abd. ♂ 23-29. ♀ 24-27. H. w. ♂ 18-21, ♀ 20-22.

Common around Phila., June 6—Sept. 10; in copula or ovipositing July 6, 9, 11, 21, Sept. 10.

Maine to Virginia; Illinois, Texas (Bullock et al.).

10. *Argia tibialis* Rambur.

Platynemis t. Ramb. Nèvr., p. 241, 1842. *A. t.* Selys, Bull. Ac. Belg. (2) xx, p. 413, 1865. *Agrion fontium* Hagen, Syn. Neur. N. A., p. 91, 1861.

Rear of head *black*. Pterostigma *blackish*. Thorax with a mid-dorsal and a broad *humeral stripe*, and a line on second lateral suture black. Vertex black.

♂. Lilac or blue. Postocular spots and sides of thorax blue or yellow. Abdomen black, 3-7 with a transverse basal yellow ring; 9-10 *blue*. Hind margin of 10 excised. Sup. app. one-third as long as 10, *apex excised from side to side*, inner branch thickest. Inf. app. longer, thicker, directed upwards; *apex bifid*, upper branch longer and thicker.

♀. Blue or reddish; similar to ♂, 3-7 with a transverse basal ring and an incomplete mid-dorsal line, yellow; 9 black, 10 yellow.

Abd. ♂ 26-29, ♀ 26-29. H. w. ♂ 19.5-22, ♀ 21-23.

One ♂ Beatty's Mills, Crum Creek, Del. Co., Pa., June 28, 1888, by P. P. Calvert (C.). Six ♂, New Jersey, July 4 (A. E. S.)

Pennsylvania to Florida; Texas, Illinois.

11. *Argia apicalis* Say.

Agrion a. Journ. Ac. Phila. viii, p. 40, 1839. *Argia a.* Selys, Bull. Ac. Belg. (2) xx, p. 414, 1865.

Rear of head *yellowish*. Pterostigma *brown*. Thorax with mid-dorsal carina and an *inferior humeral spot*, black. Vertex black.

♂. Pale blue; 2-6 with a black stripe each side, 7 black, with a pale transverse basal ring, 8-10 *blue*. Hind margin of 10 excised, edges of excision much swollen.

len. Sup. app. one-third as long as 10, with a *small inferior tooth*. Inf. app. much thicker, twice longer, directed upwards; apex bifid, branches of *equal* length, upper branch thicker.

♀. Ochre-brown replacing blue of ♂; 8-9 or 10 with a black stripe each side; inferior humeral spot often small or wanting.

Abd. ♂ 26-30, ♀ 26-29.5. H. w. ♂ 20-23, ♀ 20-23.5.

Morton, ponds near Primos, Del. Co., Pa., June 24—Sept. 10. Fairmount Park, Phila., by P. Laurent. District of Columbia, Virginia, Illinois, Texas (A. E. S., C.).

b. Black predominating on thoracic dorsum.

12. **Argia bipunctulata** Hagen.

Agrion b. Hagen, Syn. Neur. N. A., p. 90, 1861. *Argia b.* Selys, Bull. Ac. Belg. (2) xx, p. 415, 1865.

Rear of head mostly pale. Pterostigma reddish brown. Thorax with a very wide mid-dorsal and a *wide humeral stripe*, and a line on second lateral suture, black. Vertex black.

♂. Blue; a basal spot on 1, 2-6 at apex, 7, except at base, black. Hind margin of 10 excised. Sup. app. one-third as long as 10, cylindrical. Inf. app. longer, thicker, apex excised, *lower branch thicker*. A *pale blue bifid tubercle between sup. app.*

♀. Yellow replacing blue of ♂; 6, and even 4 and 5, like 7. 9-10 black.

Abd. ♂ 20-22, ♀ 20-22. H. w. ♂ 14.5-16, ♀ 15-17.

Atco and Berlin, N. J., July 12, 17, by P. Nell and P. P. Calvert (C.). Three ♂ 1 ♀ Pa. (A. E. S.)

Georgia, Florida.

5. **Erythromma** Charpentier.

Charp. Lib. Eur. p. 20, 1840. Selys, Bull. Ac. Belg. (2) xli, p. 1300, 1876.

Erythromma? conditum Hagen.

E. ? c. Hagen, Bull. Ac. Belg. (2) xli, p. 1305, 1876.

Blue or yellow. the following black: *nasus*, vertex, head behind and beneath, a broad mid-dorsal thoracic band wider above and with irregular margins, and a mark under each wing-base.

♂. Prothorax with hind margin entire, rounded. Ab. seg. 1 with a basal spot, dorsum of 2-7 (except at base) and of 10, black. Sup. app. *as long as* 10, apex dilated and curved inwards. Inf. app. a little shorter, straight.

♀. Prothorax with hind margin five-lobed, mid-dorsal lobe largest. Dorsum of 1-10 black, of 10 cleft to base.

Abd. ♂ 28-29.5, ♀ 27-29.5. H. w. ♂ 20-22.5, ♀ 22-23.

Maine (Miss Wadsworth), Maryland, District of Columbia.

6. **Nehalennia** Selys.

Selys, Rev. Odon. d'Eur. p. 172, 1850; Bull. Ac. Belg. (2) xli, 1235, 1876.

13. **Nehalennia irene** Hagen.

Agrion i. Hagen, Neur. N. A., p. 74, 1861. *N. i.* Selys, *l. c.*, p. 1240, 1876.

Metallic green. Frons, lips, sides of thorax inferiorly, pale blue, green or yellow. *No postocular spots*, but a yellow occipital line. 3-6 with an interrupted transverse, basal, blue or yellow ring.

♂. Hind margin of prothorax entire, either side straight, convergent at a wide angle to the middle, which is rounded. An apical spot on 8, greater part of 9, 10 almost entirely, blue. Hind margin of 10 *excised in the middle and denticulated*. Sup. app. excessively short, bifid, lower branch shorter. Inf. app. *longer*, with three apical tubercles.

♀. Hind margin of prothorax tri-lobed, middle lobe smallest. An apical spot on 9, apex of 10, blue.

Abd. ♂ 20-23, ♀ 20-22.5. H. w. ♂ 13-15.5, ♀ 14-15.

One ♂, Pa. (A. E. S.). One ♂, Berlin, N. J., July 17, by P. P. Calvert (C.).

Maine to Pennsylvania, west to South Dakota; Florida (Mrs. Slosson, Cheney, Truman et al).

14. *Nehalennia posita* Hagen.

Agrion p. Hagen, Syn. Neur. N. A., p. 77, 1861. *N. p.* Selys, Bull. Ac. Belg. (2) xli, p. 1242, 1876.

Metallic black, but frequently with a dark blue or dark green tinge. The following light green, yellow or blue: frons, lips; *a small, round, postocular spot* each side; *a short antehumeral stripe with a spot above it, the two forming a ! mark*; sides of thorax; an interrupted transverse basal ring on 3-7. *A black line* on second lateral suture.

♂. Hind margin of prothorax entire, rounded. Sometimes a blue dorsal spot on 10, hind margin with *an elevated bifid process*, similar to that of males of *Ischnura*. Sup. app. one-half as long as 10, directed downwards, with a small supereo-external tooth. Inf. app. slightly shorter.

♀. Hind margin of prothorax produced slightly in the middle. Antehumeral stripe and spot above it often united. 10 sometimes blue. Thorax and abdomen pruinose in old ♀♀.

Abd. ♂ 16.5-23, ♀ 18.5-22. H. w. ♂ 10-14, ♀ 13.5-16.

Very common around Phila., May 1—Oct. 2.

Quebec, Massachusetts, New Jersey, Pennsylvania, District of Columbia, Georgia, Florida (Provancher, Skinner—A. E. S., C.)

7. *Amphiagrion* Selys.

Selys, Bull. Ac. Belg. (2) xli, p. 284, 1876.

15. *Amphiagrion saucium* Burmeister.

Agrion s., *Ag. discolor* Burm. Handb. Ent. ii, p. 819, 1839. *Amph. s.* Selys l. c., p. 285, 1876.

Head dark brown or black, yellowish behind. Thoracic dorsum brown (♂) or reddish (♀), sides yellow. Pterostigma brown, upper, outer angle very acute, costal side longer than lower side.

♂. Abdomen bright red, frequently the extreme apical margin of 3-6, greater apical part of 7, 8-10, black, sutures red; occasionally 7-10 red with black spots each side. Sup. app. one-half as long as 10, simple, slender, directed downwards. Inf. app. longer, curved slightly upwards.

♀. Abdomen red, black near apex of 3-6, 7-9 black, 10 reddish.

Abd. ♂ 17-22.5, ♀ 20-23. H. w. ♂ 13.5-15.5, ♀ 14-17.5.

Small streams around Phila., May 14—July 14; fairly common; ovipositing June 3, 9.

Quebec to South Carolina; Ontario, Illinois, South Dakota, Colorado (Provancher, Pettit, Truman, Beales).

8. *Enallagma* Charpentier.

Charp. Lib. Eur. p. 21, 1840. Selys. Bull. Ac. Belg. (2) xli, p. 496, 1876.

A. ♂—2 with black on dorsum restricted to an apical spot, 8-9 blue. ♀—2 with a dorsal black band for its entire length.

a. 4-5 antenodal cells.

16. *Enallagma durum* Hagen (Pl. III, fig. 32).

Agrion d. Hagen, Syn. Neur. N. A., p. 87, 1861. *E. d.* Selys, l. c. p. 500, 1876.

Cuneiform post-ocular spots usually united by a transverse line. Vertex, a broad mid-dorsal (but with the *carina blue or yellow*) thoracic and a humeral stripe, black.

♂. Blue with the following black: a basal spot on 1, wider than long; a rounded apical spot, with an apical "tail," on 2; apical part of 3-6, *pointed anteriorly*; 7, except a transverse basal ring; 10 dorsally. Sup. app. one-fourth to one-third as long as 10, broad, excavated within, apex *truncated obliquely, inferior apical angle with a pale tubercle*. Inf. app. *a little longer*, apex acute, curved inwards.

♀. Yellowish red. Dorsum of 1-9 with a broad black band widened before the apices, an interrupted transverse basal yellow ring on 3-7. Dorsum of 10 mostly *yellowish or green*.

Abd. ♂ 26-32.5, ♀ 23-33. H. w. ♂ 18-22.5, ♀ 21-24.5.

Two ♀, Fort Mifflin, Phila., Aug. 31, 1891, by P. P. Calvert (C.).

Quebec, Rhode Island, New Jersey, Maryland, Virginia, Florida, Louisiana (Provancher, Johnson—A. E. S., C.).

b. 3 antenodal cells. ♀ with dorsum of 10 black.

17. *Enallagma civile* Hagen (Pl. III, fig. 31).

Agrion c. Hagen, Syn. Neur. N. A., p. 88, 1861. *E. c.* Selys, Bull. Ac. Belg. (2) xli, p. 514, 1876.

Cuneiform postocular spots usually connected by a transverse line. Vertex, a broad mid-dorsal thoracic and a humeral stripe, black.

♂. Blue, the following black: a square basal spot on 1; a rounded apical spot, with or without an apical "tail," on 2; apical part of 3-6; 7, except a transverse basal ring; 10 dorsally. Sup. app. shorter than 10, compressed, *broadly bifid at apex*, upper branch longer, *with a pale tubercle between the branches*. Inf. app. *a little shorter*, apex acute, curved upwards.

♀. Green or reddish yellow. Mid-dorsal thoracic carina sometimes green. Dorsum of 1-10 *black*, widened before apices, 3-7 with an interrupted, transverse, basal pale ring.

Abd. ♂ 22-28.5, ♀ 24.5-30. H. w. ♂ 15-20, ♀ 18-21.

Near Phila. May 26-27 (A. E. S.). Wayne, June 29, and Ridley Twp., Del. Co., Pa., Aug. 31—Sept. 10, by P. P. Calvert (C.). In coitu May 26, June 29, Sept. 7.

Quebec to Virginia, west to South Dakota; California, New Mexico, Texas, Mexico, Cuba, Porto Rico (Provancher, J. P. Moore, Truman, Cockerell, Kolbe).

Note.—Specimens collected by the writer at Saratoga Lake, N. Y., Aug. 15, 1889, have, in the males, the apical half to two-thirds of 3-6 black, the two branches of the sup. app. of nearly equal length, and, in the females, the post-ocular spots circular, unconnected. The writer believes them to be merely a variety of *civile*, and Dr. Hagen agreed with this opinion.—*Civile* often has the postcostal cross-vein as nearly under the first antecubital as in *E. durum*.

Enallagma Hageni Walsh (Pl. III, figs. 22, 23).

Agrion H. Walsh, Proc. Ent. Soc. Phila. ii, p. 234, 1863 (Proc. Ac. Phila., 1862, p. 386). *E. H.* Selys, Bull. Ac. Belg. (2) xli, p. 512, 1876.

Circular or cuneiform post-ocular spots not connected. Vertex, a mid-dorsal thoracic and a humeral stripe, black.

♂. Blue or green, the following black: a basal spot wider than long on 1; a rounded apical spot, with or without an apical "tail," on 2; apical part of 3-6; 7, except a transverse basal ring; 10 dorsally. Sup. app. one-half as long as 10, *quadrangular, depressed*, apical angles rounded, an internal basal rounded tubercle. Inf. app. a little longer, slender, apices acute, curved inwards.

♀. Green or reddish yellow. Dorsum of 2-10 with a broad *black* band, a transverse basal yellow ring on 3-7.

Abd. ♂ 22-25, ♀ 20-24. H. w. ♂ 15-18.5, ♀ 16.5-18.

Quebec, Maine, Massachusetts, New Hampshire, Delaware, Maryland, Illinois, South Dakota, Wisconsin (Miss Wadsworth, Mrs. Slosson, Harvey, Owen, Truman, Cheney—A. E. S., C.).

Enallagma aspersum Hagen (Pl. III, fig. 30).

Agrion e. Hagen, Syn. Neur. N. A., p. 97, 1861. *E. a.* Selys, Bull. Ac. Belg. (2) xlii, p. 518, 1876.

Cuneiform postocular spots *confluent with the blue or green of the rear of the head*. Vertex, a broad mid-dorsal thoracic and a humeral stripe, black.

♂. Blue, the following black: a basal quadrangular spot on 1; a rounded apical spot, with an apical "tail," on 2; at least the *apical half* of 3; 4-6, except an interrupted, transverse basal ring; *basal half to quarter* of 7; 10 dorsally. Sup. app. *as long as* 10, compressed, apex thickened, obtuse; *an inner inferior, subquadrangular, basal process*. Inf. app. reaching as far as end of this process, slender.

♀. Green; postocular spots sometimes separated from rear of head and then serrate on the edge. Dorsum of 1-10 with a broad *black* band, *reduced to a narrow stripe on greater basal part of 7 and 8*; a pale transverse basal ring on 3-6.

Abd. ♂ 24.5-27, ♀ 23.5-24. H. w. ♂ 17.5-20, ♀ 18.

Two ♂, Pa., June 10 (A. E. S.).

New Hampshire to Virginia; Illinois (Williamson, Skinner, Richardson, Babcock, Calvert).

B. ♂ ♀. A dorsal black band on 2 for its entire length. Usually 3 antenodal cells. ♀ with dorsum of 10 blue, green, or yellow.

18. Enallagma divagans Selys, (Pl. III, figs. 25, 26).

E. d. Selys, Bull. Ac. Belg. (2) xli, p. 521, 1876.

Cuneiform postocular spots almost connected. Vertex, a mid-dorsal thoracic and a humeral stripe, black.

♂. Blue, dorsum of 1-7, 10, black; an interrupted transverse basal blue ring on 3-7. Sup. app. *shorter than 10, not bifid*, but with inner lower side produced (= lower branch of *exsulans*). Inf. app. *a little longer than sup. app.*, apices curved inwards.

♀. Yellow or blue. *Mid-dorsal thoracic carina, and a stripe superimposed upon the humeral stripe* (so that the black thereof is reduced to a line on each side of the red), *reddish*. Dorsum of 1-8 dark metallic green or black; basal half of 9 with a dark spot, which is *bifid posteriorly*. 10 pale dorsally.

Abd. ♂ 19.5-24.5, ♀ 22-28. H. w. ♂ 14-17, ♀ 18-20.

One ♂ 1 ♀, Little Crum Creek, Ridley Twp., Del. Co., Pa., in company with *E. exsulans*, July 3, 1893, by P. P. Calvert (C.); 2 ♂, Pa., June 16, probably by S. F. Aaron (A. E. S.).

Massachusetts (Selys).

19. Enallagma exsulans Hagen (Pl. III, fig. 29).

Agrior e. Hagen, Syn. Neur. N. A., p. 82, 1861. *E. e.* Selys, Bull. Ac. Belg. (2) xli, p. 522, 1876.

Cuneiform postocular spots almost connected. Vertex, a mid-dorsal thoracic and a humeral stripe, black.

♂. Blue or green, dorsum of 1-8, 10, black; a transverse basal blue or yellow ring on 2-7. Sup. app. *shorter than 10, bifid*, upper branch half shorter than the lower. Inf. app. *as long as the upper branch*, directed upwards. Hind margin of 10 somewhat elevated and bifid, but not as much as in *Ischnura*.

♀. Yellow, lilac, blue or green. *Mid-dorsal thoracic carina and a stripe superimposed upon the humeral stripe* (so that the black thereof is reduced to a line on each side of the red), *reddish*. Dorsum of 1-9 dark metallic green or black, narrower at or absent on apex of 9 but *not bifid*, of 10 blue or green.

Abd. ♂ 24-30, ♀ 24.5-28.5. H. w. ♂ 16.5-19.5, ♀ 18-20.5.

Darby, Crum and Stone Creeks, Tinicum Is., Pa., June 6—Aug. 17; ovipositing June 28, July 6, 15.

Maine, New York to Virginia, Illinois, Texas (Miss Wadsworth, Calvert).

20. Enallagma signatum Hagen (Pl. III, fig. 28).

Agrior s. Hagen, Syn. Neur. N. A., p. 84, 1861. *E. s.* Bull. Ac. Belg. (2) xli, p. 525, 1876.

Cuneiform postocular spots connected. Vertex, a broad mid-dorsal thoracic and a humeral stripe, black or metallic brown.

♂. Blue or yellow. Dorsum of 1-8, 10, metallic brown or black; a transverse, basal blue or yellow ring on 3-7. Sup. app. *a little longer than 10*, compressed, superior margin *straight*, inferior margin very slightly divergent, apex obliquely

truncated from below upwards and backwards (distally), a small tooth at the inferior angle, extreme (upper) apex forming a small hook on the inner side. Inf. app. half shorter, slender, simple, curved inwards.

♀. Blue or yellow. Dorsum of 1-9 metallic brown, narrower at or absent on apex of 9, of 10 yellow: a transverse basal yellow ring on 3-7.

Abd. ♂ 26-30, ♀ 24-27.5. H. w. ♂ 16-18, ♀ 17-20.

Tinicum Is., Primos, Del. Co., Pa.; Fort Mifflin, Phila., etc., June 11—July 11, Aug. 31, by P. P. Calvert; ovipositing or in coitu June 17, July 5, 11.

Maine, Massachusetts, Maryland, Georgia, Louisiana, Illinois (Harvey, Hitchings).

Enallagma pollutum Hagen (Pl. III, fig. 27).

Agrion p. Hagen, Syn. Neur. N. A., p. 83, 1861. *E. p.* Selys, Bull. Ac. Belg. (2) xli, p. 527, 1876.

Very similar to *E. signatum*. ♂. Sup. app. hardly longer than 10, upper side curved upwards, lower side divergent, so that the height of the apex (profile view) is twice as great as at base; upper apical angle more prominent.

♀. Not as yet separable from that of *signatum*, as the characters suggested by de Selys—that *pollutum* has a black line on the second lateral suture which is wanting in *signatum*, and a difference in width in the dorsal abdominal band—are not constant.

Abd. ♂ 22.5-26.5, ♀ 22.5-23.5. H. w. ♂ 13.5-16.5, ♀ 15.5-16.

Maine (Harvey), Florida.

9. Ischnura Charpentier.

Charp. Lib. Eur. p. 20, 1840. Selys, Bull. Ac. Belg. (2) xli, p. 258, 1876. *Micronympha* Kirby, Cat. Odon. p. 140, 1890.

21. Ischnura verticalis Say.

Agrion v. Say, Journ. Ac. Phila., viii, p. 37, 1839. *A. v.*, *A. Ramburii* Hagen, Syn. Neur. N. A., p. 82, 76, 1861. *I. v.* Selys, l. c. p. 265, 1876.

♂. Black. Frons, lips, postocular spots, rear of head, a narrow antehumeral stripe (rarely interrupted at its middle), sides of thorax, blue or green. A black line below one or both wings. 3-7 with an interrupted basal yellow ring; 8-9 blue with a black stripe each side. Sup. app. one-fourth as long as 10, lamellate. Inf. app. a little longer, rather thick at base, outer lower side prolonged to form the acute apex, which is curved inwards, *not divided*. Pterostigma of front wings black, of hind wings yellowish brown.

Black ♀. Colored like ♂ (teneral), or greater part of body pruinose, a transverse, apical, black ring on 3-7, 8-10 blackish. Pterostigma of all the wings yellowish brown.

Orange ♀. Blue of head replaced by orange, postocular spots confluent with rear of head. Thoracic dorsum orange, a median band and a humeral stripe, black. 1, 2 and base of 3 orange on dorsum, remainder of abdomen black, 4-7 with an interrupted basal ring. Pterostigma yellowish brown on all the wings.

Abd. ♂ 19.5-22.5, Bl. ♀ 17.5-23.5, Or. ♀ 18.5-22.5. H. w. ♂ 11.5-14.5, Bl. ♀ 13.5-17, Or. ♀ 12.5-17.5.

Very common; streams and ponds around Phila., earlier than May 1—Oct. 16. Ovipositing May 1, 19, 30, June 22, 29, July, Aug. 31, Sept. 7.

Quebec to Georgia, west to Missouri and Louisiana.

22. *Ischnura Ramburii* Selys.

Agrion R. Selys, Rev. Odon. d'Eur. p. 186, 1850; *I. R.* Bull. Ac. Belg. (2) xli, p. 272, 1876. *Agrion iners, tuberculatum, credulum* Hagen, Syn. Neur. N. A., p. 75, 76, 80, 1861.

♂. Black. Frons, lips, postocular spots, rear of head, a narrow antehumeral stripe, sides of thorax. blue or green. A black line on the second lateral suture. 3-6 with an interrupted, transverse basal yellow ring; 8 *blue*. Sup. app. one-third as long as 10, apex bifid, inner branch bent down to form an inferior process. Inf. app. a little longer, thick at base, apex slender, *not divided*, curved inwards. Pterostigma of front wings black in the centre, of hind wings yellowish brown.

Black ♀. Colored like the ♂. Pterostigma of all the wings yellowish brown.

Orange ♀. Blue or green of head replaced by orange, postocular spots confluent with the rear of the head. Thoracic dorsum orange (sometimes olive), a broad median black band, but *no humeral stripe*. 1 and base of 2 orange, remainder of abdomen black, an interrupted, transverse, basal, yellow ring on 3-7. Pterostigma of all the wings yellowish brown.

Abd. ♂ 21-28, Bl. ♀ 22.5-27, Or. ♀ 22-27. H. w ♂ 13-17, Bl. ♀ 15-19, Or. ♀ 15.5-18.

Tinicum Is., Crum Creek, Pa., Aug. 23—Sept. 4.

Quebec, Ontario, New York to Florida; Louisiana, Texas, Mexico, West Indies, Venezuela, Peru (Provancher, Pettit, Johnson,). This species replaces *I. verticalis*, to a great extent, on the sea-shore.

10. *Anomalagrion* Selys.

Selys in Sagra's Hist. Cuba, Ins. p. 469, 1857; Bull. Ac. Belg. (2) xli, p. 254, 1876.

23. *Anomalagrion hastatum* Say.

Agrion h. Say, Journ. Ac. Phila. viii, p. 38, 1839. *Anom. h.* Selys, l. c. p. 255, 1876.

♂. Orange or yellow. The following dark metallic green, blue, or purple: vertex, nasus, a broad mid-dorsal thoracic and a wide humeral stripe, a mark at second lateral suture and very variable markings on base and apex of 1-7. Sup. app. half as long as 10, bifid, inner branch longer, bent downwards. Inf. app. a little longer, apex slender, curved inwards. Pterostigma on front wings *reddish, not touching the costa*; on hind wings *black, normal*.

Black ♀ (not seen by the writer). Head and thorax as in ♂, abdomen black, 3-6 with an interrupted, transverse, basal, yellow ring. Pterostigma normal, yellowish brown (Selys).

Orange ♀. Postocular spots confluent with orange of rear of the head. Thoracic dorsum orange, with a broad median metallic green stripe; sometimes a

black humeral line; sides yellow. Abdomen *orange*, 5 or 6-8 or 9 dark metallic green, 9 with a black mark each side at base. Pterostigma of all the wings normal, yellowish.

Abd. ♂ 18-22, Or. ♀ 18-21. H. w. ♂ 10-12, Or. ♀ 12-15.

Ridley Twp., Del. Co., Pa., May 17—Aug. 9, Sept. 24-25.

Maine to Florida; Indiana, Louisiana, Texas, Cuba, Hayti, Venezuela.

Subfamily 3. GOMPHINÆ.

11. **Tachopteryx** Selys.

Selys, Bull. Ac. Belg. (2) vii, p. 551, 1859.

Tachopteryx Thoreyi Hagen.

Uropetala T. Hagen, Mon. Gomph. p. 373, pl. 19, fig. 3, 1858. T. T. Selys, l. c. xlvii, p. 696, 1878.

Olive or pale lilac. Face yellowish, the following black: a transverse band on nasus, a transverse basal stripe on frons superiorly, thoracic sutures, a humeral band enclosing a yellow spot, a band on second lateral suture and on lateral meta-thoracic carina, two spots each side on 2, apical half of and a dorsal band on 3-7, most of 8-10. Triangle of hind wings of *two* cells. Pterostigma very long (8-9.5 mm) and narrow.

♂. Sup. app. longer than 10, flattened, twice as wide at two-thirds of length as at base, apex obtuse, a small submedian inferior tubercle. Inf. app. one-fifth shorter, broad, *an acute, superior, submedian, recurved tooth* each side, apex prolonged at each side to form an acute process, which is curved upwards and outwards.

♀ (not seen by the writer). Vulvar laminæ reaching base of app.

Abd. ♂ 54-58, ♀ 54-55. H. w. ♂ 51, ♀ 51-53.

Massachusetts, New York, Maryland, North Carolina (A. E. S.), Kentucky.

12. **Hagenius** Selys.

Selys, Bull. Ac. Brux. xxi, pt. 2, p. 82, 1854. Mon. Gomph. p. 238, 1858.

Hagenius brevistylus Selys.

H. b. Selys, l. c. p. 82, 1854; p. 241, pl. 13, fig. 2, 1858.

Black. The following yellow: face (except basal band on frons above and sutures), labrum, mid-dorsal thoracic carina, one or two narrow antehumeral stripes, a transverse anterior stripe, two broad lateral bands and a line between them on thorax, a dorsal stripe on 1 to base of 8, sides of 1-10.

♂ (not seen by the writer). Occiput moderate, hind border convex. Sup. app. a little shorter than 10, stout, curved slightly inwards, three inferior teeth, apex acute, curved downwards to form a hook. Inf. app. of equal length, quadrangular, broader than long, apex upcurved.

♀. Occiput small, upper surface concave, hind border hardly concave, on each side a small, posterior, rounded tubercle. Vulvar lamina not as long as half of 9, nearly quadrangular, somewhat narrower at apex, apical margin concave, or even bifid for one-third the length of the lamina.

Abd. ♂ 54-56, ♀ 54.5-63. H. w. ♂ 47-50, ♀ 50-55.

Maine, Massachusetts, New York, Ontario, Wisconsin, Kansas, Texas, Fla., Kentucky, Maryland. (Miss Wadsworth, Mrs. Slosson).

13. *Ophiogomphus* Selys.

Selys, Bull. Ac. Brux. xxi, pt. 2, p. 39, 1854. C. R. Soc. Ent. Belg. xxii, p. lxiv, 1879.

Ophiogomphus rupinsulensis Walsh.

Herpetogomphus r. Walsh, Proc. Ac. Phila. 1862, p. 388. *O. r.* Selys, Bull. Ac. Belg. (2) xlvi, p. 434, 1878.

Greenish yellow. Thorax with a humeral stripe, frequently an antehumeral stripe, and a line on second lateral suture, brown. Abdomen brown, an elongated dorsal yellow spot, pointed posteriorly, on 1-8 or 10.

♂. Sup. app. a little longer than 10, robust, *apex obtuse*, apical half denticulated below. Inf. app. *not as wide* as divergence of sup. app., its branches *truncated* to form the acuter angle at inner side, space between branches *half as wide* as either branch.

♀. Occiput with *a short yellow spine* each side. Vulvar lamina almost as long as 9, triangular, bifid in more than its apical half, the branches contiguous, but their *extreme tips divergent*.

Abd. ♂ 35-38, ♀ 35-38. H. w. ♂ 28-33.5, ♀ 32.

Quebec, Maine, New York, New Jersey, Pennsylvania, Ontario, Illinois, Wisconsin (Provancher, C. W. Johnson, A. E. S.).

14. *Gomphus* Leach.

Leach, Edinb. Eucyc. ix, p. 137, 1815; Amer. ed. (Phila.) viii, pt. ii, p. 726, 1816. Selys, Mon. Gomph. p. 115, 1858.

A. Abdominal segments 7-9 not greatly dilated (i. e. not 3-4 times as wide as 4).

a. Dorsum of 10 mostly black. Occiput not denticulated behind.

Gomphus naevius Hagen.

G. n. Hagen, Bull. Ac. Belg. (2) xlvi, p. 462, 1878.

♀. Greenish yellow. The following black: suture between frons and nasus, base of labrum, frons above at base, vertex, occiput. *No spines* on vertex. Hind margin of occiput slightly concave. Blackish brown predominating on thoracic dorsum so as to leave a transverse anterior, an isolated antehumeral and a humeral stripe, yellowish; sides greenish with three brown stripes. Abdomen black; 3-9 with a transverse basal ring, sometimes medially interrupted, 2, 3 and 8 with a mid-dorsal spot—yellow. App. white or yellow. Vulvar lamina *one-fifth* as long as 9, *apical half* bilobed, tips rounded.

♂. Unknown.

♀. Abd. 25, h. w. 21.

Maine (Harvey), York and Berks Cos., Pa. (Hagen *l. c.*)

Gomphus parvulus Selys.

G. p. Selys, Bull. Ac. Brux. xxi, pt. 2, p. 56, 1854; (2) xlvi, p. 459, 1878; Mon. Gomph. p. 157, 1858.

Black predominating, the following yellow: a transverse stripe on frons above, on nasus and on labrum; on thorax a transverse, medially-interrupted anterior,

a narrow antehumeral, a humeral and three lateral stripes; 1-8 with a dorsal spot or line and sides of 1-4. Costa black. App. blackish.

♂. Sup. app. straight, cylindrical, apex becoming *gradually acute, no teeth or spines*. Inf. app. less than half as long.

♀ (not seen by the writer). *No spines on vertex*. Hind margin of occiput almost straight. Vulvar lamina *half* as long as 9, *almost completely divided* into two oval divergent lobes.

Abd. ♂ ♀ 28. H. w. ♂ ♀ 26.

Nova Scotia to New Hampshire, Berks and York Cos., Pa.

24. *Gomphus abbreviatus* Hagen.

G. a. Hagen, Bull. Ac. Belg. (2) xlvi, p. 464, 1878.

Yellow, including *most of labium*. Vertex black. *No black stripe* on suture between frons and nasus. Dark brown predominating over yellow on thoracic dorsum and forming two confluent submedian dorsal stripes, an antehumeral and a humeral, confluent, a line in front of the metastigma and on the second lateral suture. Abdomen black, a mid-dorsal and a lateral basal yellow spot on 1-6 or 8, sides of 8 and 9 yellow. Costa black. Pterostigma yellow to reddish brown.

♂. Hind margin of occiput convex. Sup. app. with apex acute and an *inferior spine-like tooth* at two-thirds their length. Inf. app. shorter.

♀. A spine on each side of vertex. Hind margin of occiput almost straight. Vulvar lamina *one-third* as long as 9, triangular, *apical half* bifid, the halves contiguous.

Abd. ♂ 26-33, ♀ 28-29. H. w. ♂ 22-25, ♀ 25-25.5.

One male, Phila. (A. E. S.), probably belongs to this species.

Maine, Massachusetts.

b. Dorsum of 10 mostly yellowish or reddish. No spines on vertex of female.

25. *Gomphus exilis* Selys (Pl. II, fig. 11).

G. e. Selys, Bull. Ac. Brux. xxi, pt. 2, p. 55, 1854; (2) xxxv, p. 748, 1873.

Pale green. Vertex brown. Hind margin of occiput *nearly straight*. Brown predominating on thorax and forming two median dorsal stripes, widening downwards, an antehumeral and a humeral stripe barely separated by a pale line, and most of the sides, leaving two oblique, lateral, green bands, one behind the humeral, the other behind the second lateral suture. Abdomen blackish brown, 1-10 with a basal dorsal green spot or band.

♂. Sup. app. with an inferior tooth-like *process* at two-fifths their length, the apical side of the process *sloping gradually* to apex of app.

♀. Vulvar lamina short, *not longer than one-fifth* of 9, bilobed, lobes not contiguous, *as long as or a little longer than wide*. tips roundly pointed.

Abd. ♂ 29-30.5, ♀ 28.5-30. H. w. ♂ 23-24, ♀ 24-25.5.

The most common Gomphine around Phila., May 26—July 4.

Quebec, Maine, Massachusetts, New Jersey, Pennsylvania, Maryland, Florida (Miss Wadsworth, Skinner, Laurent).

26. Gomphus minutus Rambur.

G. m. Ramb., Ins. Nev., p. 161, 1842. Selys, Mon. Gomph., p. 155, pl. 9, fig. 3, 1858.

Pale green or yellow. Vertex brown. Hind margin of occiput *decidedly concave*. Brown predominating on thorax. Thorax and abdomen similar to *exilis* in coloring. A character upon which stress was originally laid by de Selys—that the sides of the thorax were mostly yellowish, with two brown bands—is not constant.

♂ (not seen by the writer). Sup. app. with a strong, acute, submedian, inferior tooth.

♀. Vulvar lamina *very short*, hardly bilobed, lobes *much wider than long*.

Abd. ♂ 35, ♀ 35-37. H. w. ♂ 28, ♀ 30-32.

One female, Phila., July 1, S. F. Aaron (A. E. S.). One female, Phila., June 22, 1893, C. W. Johnson (C.).

Pennsylvania, Georgia.

27. Gomphus plagiatus Selys.

G. p. Selys, Bull. Ac. Brux. xxi, pt. 2, p. 57, 1854; (2) xlv, p. 465, 1878.

Olive-green. Brown predominating on thoracic dorsum so as to leave a narrow antehumeral stripe, *notably divergent from above downwards from its fellow of the opposite side*, and the mid-dorsal carina yellow (teneral) or green; sides pale, a line in front of the metastigma and on the second lateral suture, brown. Abdomen long, 1-6 brown with a pale green mid-dorsal spot or stripe, 7-10 *yellowish*.

♂. Hind margin of occiput slightly convex. Sup. app. without teeth, apex *obliquely truncated* (when viewed from above), the acuter angle on the inner side, usually no tubercle at the outer (obtuse) angle. Inf. app. one-fourth shorter.

♀. Hind margin of occiput straight. Vulvar lamina *very short, less than one-tenth* of 9, emarginated in the middle, tips on either side of emargination acute.

Abd. ♂ 40-45, ♀ 44-49. H. w. ♂ 32-35, ♀ 35.5-37.

One ♂ one ♀, Fairmount Park, P. Laurent, C. W. Johnson; one ♂ one ♀, Phila., P. Nell; one ♂, Folsom, Del. Co., Pa., July 17, 1886, P. P. Calvert (C.).

Pennsylvania, Maryland, South Carolina, Tennessee, Florida, Texas (A. E. S.).

28. Gomphus villosipes Selys.

G. v. Selys, Bull. Ac. Brux. xxi, pt. 2, p. 53, 1854; (2) xlv, p. 457, 1878.

Yellowish green. Hind margin of occiput with a *median conical tubercle*. Green predominating on the thorax, but with the following brown: a submedian, an antehumeral and a longitudinally-divided humeral stripe, and sometimes some lines on the sides. Abdomen dark brown, 1-7 with a mid-dorsal yellowish green spot or stripe, 10 yellowish.

♂. Sup. app. *without teeth*, apex *obliquely truncated* when viewed from above, the acuter angle on the inner side and prolonged into a spine, which is bent somewhat inwards, a *rounded tubercle* at the outer (obtuse) angle. Legs *mostly black*.

♀. Vulvar lamina *hardly one-third* as long as 9, triangular, bifid in its *apical third*, the halves contiguous.

Abd. ♂ 37-39, ♀ 38. H. w. ♂ 30-33, ♀ 33.5.

Ditches at Tinicum Is., woods at Folsom, ponds at Primos, Del. Co., Pa., June 7—July 5, P. P. Calvert; not abundant (C., A. E. S.).
Massachusetts, Michigan.

B. Abdominal segments 7-9 greatly dilated (i. e. 3-4 times wider than 4).

29. *Gomphus vastus* Walsh.

G. v. Walsh, Proc. Ac. Phila. 1862, p. 391.

Frons and nasus greenish yellow, basal superior half of the former and a broad band at suture between them, *black*. Labrum margined with black. Thorax yellow and dark brown, the latter predominating dorsally and forming two confluent, median, dorsal bands widening below, a broader antehumeral, a narrower humeral stripe, a line in front of the metastigma and one on the second lateral suture. Abdomen black, a mid-dorsal yellow spot or line on 1-7 or 8, 8 and 9 with a large lateral, yellow spot, 9 and 10 *unspotted dorsally*. Wings slightly yellowish at base.

♂. Sup. app. with acute apex and an *extremely small, externo-inferior, ante-apical spine*.

♀. Vertex sometimes with a spine each side. Vulvar lamina *slightly more than half* as long as 9, rather narrow, *apical sixth* bifid, tips acute.

Abd. ♂ 37, ♀ 35-37. H. w. ♂ 29-31, ♀ 31-32.

One male flew in a shop at Sixth and Chestnut Sts., Phila., May 28, 1891; P. Nell (A. E. S.).

Quebec (Provancher), New York, District of Columbia, Illinois.

15. *Dromogomphus* Selys.

Selys, Bull. Ac. Brux. xxi, pt. 2, p. 58, 1854.

30. *Dromogomphus spinosus* Selys.

D. s. Selys, *l. c.* p. 59, 1854. *Gomphus s.* Selys, Mon. Gomph. p. 120, pl. 7, fig. 2, 1858.

Face, lips, occiput yellowish or green, vertex black. At most a very narrow black line between frons and nasus. Thoracic dorsum maroon-brown; mid-dorsal carina, anterior border (these two confluent), an *isolated* submedian stripe, an *isolated* antehumeral line, and the sides, yellow or green. Abdomen blackish, a dorsal maculate yellow band on 1-10. Wings sometimes faintly yellowish at base.

♂. Hind margin of occiput convex, no tubercle. Sup. app. divergent, an *obtuse inferior median thickening*, apex acute, upturned.

♀. Vertex with an *erect spine* behind each lateral ocellus. Occiput with a *median pointed tubercle*. Vulvar lamina *one-third* as long as 9, its *apical half* bifid, branches slightly divergent, tips acute.

Abd. ♂ 39-41.5, ♀ 41.5-45. H. w. ♂ 32-34.5, ♀ 35-39.

Fairmount Park and elsewhere in Phila., June 10, 26, S. F. Aaron, P. Laurent, P. Nell; not common (A. E. S., C.).

Maine, Massachusetts, New Jersey, Pennsylvania (York, etc.), Georgia, Florida, Kentucky, Illinois (Miss Wadsworth, Hitchings, G. Miller, Babcock.—W. I.).

Subfamily 4. CORDULEGASTERINÆ.

16. **Cordulegaster** Leach.

Leach. Edinb. Encyc. ix, p. 136, 1815; Amer. ed. (Phila.) viii, pt. ii, p. 725, 1816. Selys, Mon. Gomph. p. 328, 1858. *Thecaphora* Selys, l. c. p. 319.

Cordulegaster maculatus Selys.

C. m. Selys, Bull. Ac. Brux. xxi, pt. 2, p. 105, 1854; (2) xlv, p. 689, 1878.

Blackish brown; the following yellow: *rear of head, frons* (except a very narrow basal black band above), *nasus*, *labrum* (except an anterior brown border and mid-basal spot), a cuneiform antehumeral stripe, wider above, two oblique, lateral, thoracic bands and an intermediate line, two pairs (median and apical) of spots on 2-5 and sometimes 8, one pair on 6-9.

♂. Sup. app. shorter than 10, straight, two strong inferior teeth, one basal, the other submedian. Inf. app. one-third shorter, *tip nearly as wide as base*. Spines of anterior row on second and third tibiæ replaced by knobs.

♀. Vulvar laminæ long, projecting considerably beyond 10.

Abd. ♂ 47.5-53, ♀ (incl. vulv. lam.) 55.5-60.5. H. w. ♂ 37-41, ♀ 43-45.

Nova Scotia, New England, Ontario, Maryland, Georgia.

Cordulegaster erroneus Hagen.

C. e. Hagen, Bull. Ac. Belg. (2) xlv, p. 688, 1878.

Blackish brown. *Frons* yellow above, black anteriorly. *Labrum* yellow, entirely margined and almost crossed with black. *Rear of head black*. The following yellow: *nasus*, *labium*, *occiput*, a cuneiform antehumeral stripe, wider above and divergent from above downwards, two broad, oblique, lateral, thoracic stripes, two pairs of spots on 2-4, one pair on 5-8, anterior pair on 2-4 larger, meeting (or almost so) on dorsal carina, so also the pair on 5-7.

♂. Sup. app. a little shorter than 10, two small inferior teeth, one basal, the other submedian. Inf. app. one-fourth shorter, *tip half as wide as base*. Spines of anterior row of second and third tibiæ replaced by knobs.

♀ (not seen by the writer). Vulvar laminæ long, projecting beyond 10.

Abd. ♂ 53-56, ♀ 64. H. w. ♂ 44-47, ♀ 51.

Pocono Mts., Pike Co., Pa., August, E. M. Aaron (A. E. S.); North Carolina, Kentucky.

Subfamily 5. AESCHNINÆ.

17. **Epiæschna** Selys.

Selys, Proc. Bost. Soc. Nat. Hist. xviii, p. 36, 1875. Karsch, Ent. Nach. xvii, p. 290, 1891.

31. **Epiæschna heros** Fabricius.

Aeschna h. Fabr., Ent. Syst. Suppl. p. 285, 1798. Hagen, Syn. Neur. N. A., p. 128, 1861.

Face brown and green. Frons above with a black T-spot. Thorax brown; an antehumeral stripe wider above, two bands on the sides, and inter-alar spots—green. Abdomen dark brown marked with blue or green spots and lines. Wings smoky or yellowish to a varying extent, extreme apex sometimes darker. Pterostigma orange to reddish brown. Membranule white. App. as long as, or longer than $9 + 10$.

♂. Rear of head simple. 10 with a mid-dorsal tooth. Sup. app. with apical two-thirds wider, an inferior tubercle near base, apical half with a superior, longitudinal carina and the inner edge hairy, apex truncated. Inf. app. one-half shorter, oblong, apex notched.

♀. Rear of head produced on either side of the occiput in an obtuse angle, which projects beyond the latter. 10 with a ventral, plate-like *denticulated* projection. App. oblanceolate.

Abd. ♂ 61–71, ♀ 64–72. H. w. ♂ 53–60, ♀ 58–62.5.

Fairly common around Phila., May to September.

Quebec to Mexico, west to the Mississippi.

18. *Fonscolombia* Selys.

Selys, Bull. Ac. Belg. (3) v, p. 736, 1883. Karsch, Ent. Nach. xvii, p. 239, 1891.

32. *Fonscolombia vinosa* Say.

Aeshna v. Say, Jour. Ac. Phila., viii, p. 13, 1839. *Ae. quadriguttata* Burm. Hagen, Syn. Neur. N. A., p. 130, 1861.

Face greenish or brownish, lips yellow. Frons above with a brown spot. Thorax brown, an indistinct pale green, antehumeral stripe, sides with *two round bright yellow spots*. Abdomen constricted at 3, spotted with yellow. Wings with reddish veins, a small basal reddish brown or smoky spot, tips sometimes clouded. Pterostigma yellow, 4–5.5 mm. long. Triangle of 4–6 cells; at least *one* basal subcostal cross-vein.

♂. Sup. app. as long as $9 + 10$, wider in apical two-thirds, apex hardly acute, a small inferior tooth near base. Inf. app. one-third as long, triangular, apex notched.

♀. A small brown spot at nodus.

Abd. ♂ 44–51, ♀ 48.5–50. H. w. ♂ 40–42, ♀ 41–44.

One male, Phila., Aug. 26; one female, Mt. Holly, N. J., July 4, S. F. Aaron (A. E. S.). One male, Fairmount Park, Aug. 29, 1891, P. Nell. One female, Clementon, N. J., S. F. Gross (C.).

Canada; Eastern United States; Fort Townson, Arkansas (Uhler's coll.).

19. *Gomphaeschna* Selys.

Selys, Trans. Ent. Soc. Lond., 1871, p. 413. Karsch, Ent. Nach. xv, p. 238, 1889.

33. *Gomphaeschna furcillata* Say, var *antilope* Hagen.

G. a. Hagen, Proc. Bost. Soc. N. H., xvi, p. 354, 1874.

Face yellowish brown. Frons above with a black T-spot. Thorax brown, an antehumeral green stripe; sides yellowish or brown, two median oblique black bands confluent above and below the metastigma. Abdomen dark brown, marked with blue or green spots. Pterostigma yellow to blackish brown.

♂. Sup. app. slender, *almost straight*, widened in their apical half, a small inferior tooth near base, apex rounded. Inf. app. less than half as long, apical half bifid, appendage narrowed a little at level of base of bifurcation, branches moderately divergent. Anal triangle of 1-2 cells; 4-6 postcubitals on front wings.

♀. A *brownish yellow cloud* around nodus; front wings with 9-13 antecubitals. Abd. ♂ 42-44, ♀ 40. H. w. ♂ 34-36, ♀ 36.

One male, Clementon, N. J., S. F. Gross (C.).

New Jersey, Maryland, Virginia (T. R. Peale, C. W. Johnson—A. E. S., C., W. I.).

N. B.—This was originally described as a distinct species from *furcillata* Say, the chief differences being that the latter had the ♂ sup. app. curved inwards and downwards, apex of inf. app. more widely emarginated, 7 (*antilope* 4) postcubitals on front wings; ♀ wings unspotted 12-13 antecubitals on front wings (*antilope* 9-10), abdomen of slightly different shape. As additional specimens are examined, the differences between the two forms become less and less.

20. *Aeschna* Fabricius.

(*Aeshna*) Fabr., Syst. Ent. p. 424, 1775. Karsch, Ent. Nach. xvii, p. 288, 1891.

A. Male with anal triangle of 2 cells, 10 with 3 basal dorsal teeth, of which the middle one is largest (the specific characters of the females have not yet been determined).

34. *Aeschna juncea* Linné, var. *verticalis* Hagen.

Ae. v. Hagen, Syn. Neur. N. A., p. 122, 1861.

Face green, frons above with a black T-spot, *no black line on fronto-nasal suture*. Thorax dark brown, an antehumeral (wider above) and sometimes a short humeral stripe, green; two green or blue lateral bands. Abdomen dark brown, marked with blue or green spots and lines; 10 with a blue spot each side of dorsum. Membranule smoky.

♂. Abdomen constricted at 3. Sup. app. as long as 9 + 10, oblong, narrower at base, margins *entire*, a superior longitudinal carina *not denticulated*, apex moderately acute. Inf. app. half as long, triangular.

♀. App. oblong, narrower at base, apex rounded.

Abd. ♂ 50-53.5, ♀ 51-55. H. w. ♂ 42-45.5, ♀ 45-46.

Ridley Twp., Del. Co., Pa., Oct. 4-18, P. P. Calvert.

Nova Scotia to the District of Columbia, Illinois.

N. B.—No constant differences are apparent between this insect and the circumpolar *Ae. juncea* L., except that the latter has a black line on the fronto-nasal suture, and perhaps a slightly longer pterostigma, and the apex of sup. app. ♂ not quite so acute.

Aeschna clepsydra Say.

Ae. c. Say, Jour. Ac. Phila. viii, p. 12, 1839. Hagen, Neur. N. A., p. 122, 1861. *Ae. crenata* Hagen, Stet. Ent. Zeit. xvii, p. 369. *Ae. eremita* Scudder, Proc. Bost. Soc. N. H., x, p. 215, 1866.*

* The evidence on which this synonymy is based will shortly be published elsewhere.

Face greenish or luteous, frons above with a black T-spot, with or without a black line on fronto-nasal suture. Thorax dark brown, an antehumeral stripe, two lateral bands and sometimes an intermediate line, blue or green. Abdomen dark brown, marked with blue or green spots and lines; 10 with a blue spot each side of dorsum, sometimes confluent.

♂. Abdomen constricted at 3. Sup. app. as long as $9 + 10$, oblong, narrower at base, margins *entire*, a superior longitudinal carina bearing 4-9 *denticles*, apex varying from rounded with extreme tip barely pointed to being prolonged into a distinct acute process which is directed somewhat downwards. Inf. app. half as long or longer, triangular.

♀. App. oblong, narrower at base, apex rounded.

Abd. ♂ 51-57.5, ♀ 50-53. H. w. ♂ 43-50, ♀ 42-46.5.

Labrador to Massachusetts, Maryland, New York, Illinois, Michigan, Wisconsin, Dakota, Saskatchewan, Irkutsk and Wilui River (Siberia), Finland (Sheraton, Brown, Dr. Mark, etc.—C., A. E. S.).

B. Male with anal triangle of 3 cells, no dorsal teeth on 10.

35. *Aeschna constricta* Say.

Ae. c. Say, Jour. Ac. Phila., viii, p. 11, 1839. Scudder, Proc. Bost. Soc. N. H., x, p. 212, 1866.

Face green or brown, frons above with a black T-spot, sometimes a black line on fronto-nasal suture. Thorax dark brown, an antehumeral green stripe, wider above, and two lateral, green, blue or yellow stripes. Abdomen dark brown, marked with green or blue spots and lines; 10 spotted or unspotted. Membrane blackish, basal half whitish.

♂. Abdomen much constricted at 3. Sup. app. as long as $9 + 10$, widened in their apical half, *emarginate on the inner edge* in front of the apex, the emargination *quite hairy* and thickened to form a tubercle at its hind end (the hairs are sometimes matted together to give the appearance of an acute tooth pointed forwards); apex with a *long, acute, inferior, slightly anteapical spine*. Inf. app. half shorter, triangular.

♀. App. oblong, narrower at base, apex rounded. Wings sometimes yellowish.

Abd. ♂ 51.5-57.5, ♀ 51-55. H. w. ♂ 42-48, ♀ 42-48.

Common around Phila., Aug. 28—Oct. 16.

Labrador to Maryland, west to Colorado; Southern California to British Columbia; Kamtschatka, Siberia (A. E. S., C.).

21. *Anax* Leach.

Leach, Edinb. Encyc. ix, p. 137, 1815; Amer. ed. (Phila.) viii, pt. 2, p. 726, 1816. Karsch, Ent. Nach. xvii, p. 287, 1891.

36. *Anax junius* Drury.

Libellula j. Drury, Ill. Exot. Ent. I, p. 112, pl. 47, fig. 5, 1770: *A. j.* Hagen, Psyche v, p. 305, 1890.

Head and thorax bright green. Frons above with a *round black spot, surrounded by yellow, the latter encircled by a dark blue ring*. 1 and base of 2 green, 3-10 blue (♂), purple or lilac (♀), with a partly interrupted, mid-dorsal, brown band. Wings often pale yellowish to a varying extent.

♂. Hind margin of occiput slightly concave. Sup. app. *abruptly narrowed on inner side* just before the apex, which is rather truncated and prolonged on the outer side into a *sharp spine*. Inf. app. one-sixth as long, quadrangular, *wider than long*, upper surface with a submedian tooth and many smaller apical teeth each side.

♀. Hind margin of occiput elevated and emarginated in the middle.

Abd. ♂ 53.5-56, ♀ 52-56. H. w. ♂ 46.5-56, ♀ 48-56.

Common around Phila., earlier than May 1—Oct. 16; in copula or ovipositing May 1, June 15, 19, 22, 28, July 6.

Quebec to Florida, west to the Pacific, Alaska to Costa Rica, W. Indies, Sandwich Is., Kamtschatka, China.

Anax longipes Hagen, recorded from Brazil, West Indies, Mexico, Florida, Maryland, Massachusetts, has the frons green, *unspotted superiorly*, in both sexes.

Subfamily 6. CORDULINÆ.

22. **Didymops** Rambur.

Ramb., Ins. Nevr. p. 142, 1842. Selys, Bull. Ac. Belg. (2) xlv, p. 211, 1878.

37. Didymops transversa Say.

Libellula t. Say, Jour. Ac. Phila. viii, p. 19, 1839. *Macromia t.* Selys, Bull. Ac. Belg. (2) xxxi, p. 548, 1871.

Grayish to brown. Nasus and frons above yellow, the latter with a *superior black T-spot*. Thorax with a small antehumeral spot (sometimes absent), an oblique, mid-lateral band, and the antealar sinuses, pale yellow or white; *no humeral stripe*. Abdomen quite slender in the middle, thickened at 7-10. 2-8 with a spot each side of dorsum and 10 entirely, yellow. A small yellow or brown basal cloud at base of front margin of wings.

♂. Sup. app. longer than 10, denticulated below, extreme apex directed upwards and outwards. Inf. app. of equal length, broad, triangular.

♀. Vulvar lamina very short, emarginated in a semicircle.

Abd. ♂ 36-38, ♀ 38-40. H. w. ♂ 31-35, ♀ 38-39.

One male, Wissahickon, Phila., May 20, 1883, S. F. Aaron; one male, Fairmount Park, May 31, 1891, Dr. H. Skinner; one male, Mt. Holly, N. J., May 13, E. M. Aaron (A. E. S.). One male, Arccla, Montgomery Co., Pa., May 19, 1893, P. Nell (C.).

Quebec to Georgia; Michigan, Kentucky, Texas (Provancher, Miss Wadsworth, Harvey, Cabot).

23. **Macromia** Rambur.

Ramb., Ins. Nevr. p. 137, 1842. Selys, Bull. Ac. Belg. (2) xlv, p. 210, 1878.

38. Macromia tæniolata Rambur.

M. t. Ramb. l. c. p. 139, 1842. *Epophthalmia t.* Selys, l. c. (2) xxxi, p. 527, 1871.

Blackish, with more or less metallic reflection. Frons above metallic blue, with *two* small yellow spots in front of the vertex. The following yellow: a transverse nasal band, a *short antehumeral stripe*, a broad band entirely around

the thorax between the front and hind wings, an interrupted, transverse ring on 2, a triangular spot each side on 3-8, usually united and larger on 7.

♂ (not seen by the writer). 10 not elevated. Sup. app. a little longer than 10, a small median external tooth; apical half curved outwards, apex moderately acute. Inf. app. hardly shorter, apex truncated, upcurved.

♀. Vulvar lamina very short, hardly emarginate. Apical two-thirds of wings pale yellow.

Abd. ♂ 64, ♀ 63. H. w. ♂ 55, ♀ 57.

Philadelphia (Hagen 37, p. 57).

Pennsylvania, Maryland, Georgia, Florida (W. I.).

39. *Macromia illinoensis* Walsh.

M. i. Walsh, Proc. Ac. Phila., 1862, p. 397. Selys, Bull. Ac. Belg. (2) xxxi, p. 546, 1871. ? *Epophthalmia georgina* Selys, l. c. (2) xlv, p. 197, 1878.

Metallic blackish brown. Nasus yellowish, obscurely bordered with black. Frons above metallic blue, with four small yellow spots in front of the vertex. The following yellow: a broad band surrounding the thorax between the front and hind wings, a lateral spot and a middle transverse line on 2, a dorsal spot each side of 3-6, a broad, basal, dorsal spot on 7. Usually no antehumeral stripe. 1 or 2 posttriangular rows.

♂. Sometimes a dorsal yellow spot on 9. 10 not elevated. Sup. app. similar to those of *tæniolata*.

♀. Vulvar lamina short, less than one-sixth as long as 9, deeply bilobed at the middle. Wings with a dark brown basal spot between costa and subcosta to first antecubital.

Abd. ♂ 45-50.5, ♀ 49-53. H. w. ♂ 41-45, ♀ 45-49.

One male, Fairmount Park, Phila., P. Laurent (C.); one male, Pennsylvania (A. E. S.).

Quebec to Massachusetts; Pennsylvania, Illinois, Tennessee (*illinoensis*); Georgia, Illinois (H. L. Walker) (*georgina*).

N. B.—The absence or presence of cross-veins in the triangles, by which de Selys has separated *Macromia* from *Epophthalmia*, is not a constant character. It remains to be seen whether *georgina* and *illinoensis* are otherwise distinct, and whether both are variations of *tæniolata*.

24. *Epicordulia* Selys.

Selys, Bull. Ac. Belg. (2) xxxi, p. 259, 1871; xlv, p. 207, 1878.

40. *Epicordulia princeps* Hagen.

Epithea p. Hagen, Syn. Neur. N. A., p. 134, 1861. *Cordulia p.* Selys, l. c. (2) xxxi, p. 275, 1871.

Olive- or yellowish brown. Abdomen swollen at base, yellowish, a mid-dorsal brown band on 3-10, interrupted by a transverse, yellow ring at each articulation. Wings with a basal, a nodal (this sometimes absent), and an apical spot of variable sizes, brown.

♂. Sup. app. nearly as long as 9 + 10, apical two-thirds dilated. Inf. app. one-third shorter, subtriangular.

♀. Vulvar lamina almost as long as 9, bilobed for its entire length. App. nearly one-and-a-half times as long as $9 + 10$.

Abd. ♂ 42-45, ♀ 42-50. H. w. ♂ 40-41, ♀ 40-46.5.

Two males, June 14, July 1, Phila.; one male, Bristol, Pa., June 16; S. F. Aaron (A. E. S.).

Quebec to Connecticut; Pennsylvania, Maryland, Georgia, Michigan, Illinois, Texas (Provancher, Miss Wadsworth, Hitchings).

25. *Tetragoneuria* Hagen.

Hagen, Syn. Neur. N. A., p. 140, 1861. *Tetragoneura* Selys, Bull. Ac. Belg. (2) xlv, p. 207, 1878.

41. *Tetragoneuria cynosura* Say.

Libellula c. Say, Jour. Ac. Phila. viii, p. 30, 1839. *Cordulia c.* Selys, l. c. (2) xxxi, p. 270, 1871. *C. lateralis* Burm., Hagen, Syn. Neur. N. A., p. 139, 1861.

Blackish brown. Face and lips pale lilac or yellowish. Usually *no superior black T spot* on frons. Thorax clothed with white hairs, a yellow spot above and one below the metastigma. A yellow spot each side of dorsum of 2-9. Hind wings with a short, superior, dark brown, basal streak to first antecubital, and an inferior, triangular, basal spot not extending beyond the level of the median cross-vein; streak sometimes shorter and spot sometimes wanting.

♂. Sup. app. as long as $9 + 10$, thickened in their apical half, *without teeth or spines*. Inf. app. one-third shorter.

♀. Vulvar lamina longer than 9, bifid almost to base, lobes divergent, somewhat bent towards each other in apical half. App. *shorter* than $9 + 10$.

Abd. ♂ 28-30.5, ♀ 26-27. H. w. ♂ 28-29, ♀ 29-30.

One male, June 28, 1886; one male, June 4, 1887; one female, May 30, 1887; one female, June 6, 1892; edge of thickets, Folsom, Pa., P. P. Calvert (C.).

Quebec to Florida; Ohio, Illinois, Michigan, Louisiana.

Tetragoneuria semiaquea Burmeister.

Libellula s. Burm., Handb. Ent. ii, p. 858, 1839. *T. s.* Hagen, Syn. Neur. N. A., p. 140, 1861.

Very similar to *T. cynosura*, but the hind wings have the basal streak extending farther out, basal spot reaching beyond the triangle, or even to beyond the nodus. Probably only a variety of *cynosura*.

Abd. ♂ 24-28, ♀ 25-28.5. H. w. ♂ 25-28, ♀ 27.5-30.

Nova Scotia, Maine, Massachusetts; District of Columbia to Fla. (Miss Wadsworth, A. E. S.).

26. *Neurocordulia* Selys.

Selys, Bull. Ac. Belg. (2) xxxi, p. 278, 1871; xlv, p. 206, 1878.

Neurocordulia obsoleta Say.

Libellula o. Say, Jour. Ac. Phila., viii, p. 28, 1839. *Epitheca o.* Hagen, Psyche. v, p. 369, pl. i, figs. 7-9, 1890,

Dull olive-brown. Thorax with mid-dorsal carina, an anterior transverse stripe, and around the metastigma, yellow.

♂ (not seen by the writer). Dorsal apical margin of 10 slightly produced in the middle and *rounded*. Sup. app. thickened in apical half, *no angular notch* at middle of lower surface. Wings with a *yellowish* spot on each antecubital and near the arculus; on hind wings also an orange spot in the triangle.

♀. Vulvar lamina very short, with a *wide, median, rectangular notch*. Wings marked as in ♂, but spots larger, and also a spot at nodus and at base of front wings, and a basal band on hind wings from anal margin to postcostal vein leaving extreme base hyaline, brown.

Abd. ♂ 30, ♀ 32-36.5. H. w. ♂ 30, ♀ 31.5-38.

One female, Pennsylvania, May 28, 1881, G. H. Parker (A. E. S.).
Massachusetts, Pennsylvania, Indiana, Illinois, Louisiana.

27. *Somatochlora* Selys.

Selys, Bull. Ac. Belg. (2) xxxi. p. 279, 1871; xlv, p. 204, 1878.

42. *Somatochlora lepida* Hagen.

Cordulia l. Hagen, l. c. (2) xxxi, p. 264, 1871.

Metallic green. Labium orange, a yellow spot each side of frons. Abdomen *not* widened before apex. All discoidal triangles *free*. internal triangle of front wings usually of 2 cells, wanting on hind wings. Base of wings sometimes pale yellow. Membranule with basal half white, apical half cinereous.

♂. Sup. app. longer than 10, slender at base, thickened beyond, a *very small inferior basal tubercle*, apex hardly acute. Inf. app. one-third shorter, subtriangular, apex quite narrow.

♀. Base of 1-2, a *spot each side* of 3-7, yellowish red. App. twice as long as 10. Vulvar lamina *a little less than half* as long as 9, *apical half bilobed*, apices rounded.

Abd. ♂ 26.5-29, ♀ 25-28. H. w. ♂ 26-28, ♀ 26-29.

One male, Atco, N. J., June 18, 1893, C. W. Johnson (C.).
Maine to New Jersey, Maryland.

Somatochlora linearis Hagen.

Cordulia l. Hagen, Syn. Neur. N. A., p. 137, 1861. *Epitheca* l., *E. procera* Selys, Bull. Ac. Belg. (2) xxxi, pp. 286, 285, 1871.

(Not seen by the writer.) Metallic green. Lips and face inferiorly brownish. Abdomen cylindrical, 2-8 with a yellow basal spot each side.

♂. Abdomen swollen at base. Sup. app. not as long as 9 + 10, arcuated at base, with *two external teeth*, one at one-third their length, the second, stronger, at two-thirds; *apex bifid*, external branch bent downwards. Inf. app. a little shorter.

♀. Vulvar lamina *a little longer* than 9, projecting almost at right angles from the abdomen, its margin *entire*.

Abd. ♂ 44-46, ♀ 42-52. H. w. ♂ 42-44, ♀ 40-51.

Pennsylvania, Georgia, Illinois, Missouri.

Somatochlora filosa Hagen.

Cordulia f. Hagen, Syn. Neur. N. A., p. 136, 1861. *Epitheca* f. Selys, Bull. Ac. Belg. (2) xxxi, p. 287, 1871.

Metallic green, blackish on hind part of abdomen. Labrum and clypeus brownish, labium yellowish. Thorax with two lateral yellow stripes, one beneath each pair of wings. Abdomen swollen and compressed at base, narrowed at 3, some yellow on the sides of 1-3.

♂. Sup. app. (4-4.5 mm.) longer than $9 + 10$, cylindrical, curved slightly outwards then inwards in the basal fourth, thickened in the middle, apical fourth more slender and slightly divergent, apex terminating in a *very small hook* which is directed inwards and downwards, and is *compressed*; no teeth on sup. app. Inf. app. a little more than half as long, triangular, apex moderately acute, curved upwards but little.

♀ (not seen by the writer). App. 4 mm. long. *Vulvar lamina* forming a compressed trough, which is a little recurved and reaches to the tip of the abdomen.

Abd. ♂ 41, ♀ 48. H. w. ♂ 38-39, ♀ 43.

One male Petersburg, N. J., Aug. 30, 1892 (P. P. Calvert), Maryland, Georgia.

Subfamily 7. LIBELLULINÆ.

28. *Pantala* Hagen.

Hagen, Syn. Neur. N. A., p. 141, 1861. Kirby, Trans. Zool. Soc. Lond., xii, p. 265, 1889.

43. *Pantala flavescens* Fabricius.

Libellula f. Fabr., Ent. Syst. Supp. p. 285, 1798. *P. f.* Hagen, l. c. p. 142, 1861.

Yellowish. Abdomen with a maculate, mid-dorsal stripe, sometimes absent on 2-7, and a ventral stripe each side of 1-8, black. Apices of wings sometimes smoky; hind wings with anal margin yellowish, *no dark brown spot*.

Abd. ♂ 29-33, ♀ 32-34. H. w. ♂ 41-42, ♀ 39.5-41.

Two males, Fairmount Park, Phila., H. D. Coyle, park guard, through C. W. Johnson (C., W. I.). One female, Fairmount Park, Aug. 29, 1891, P. Nell (C.).

Massachusetts, Pennsylvania, Maryland, Virginia, Georgia, Fla., Wisconsin, Illinois, Missouri, Texas, Mexico, West Indies; Surinam to Northern Brazil; Fijis, New South Wales, Sumatra to Banca, Sandwich Is., Philippines, Kamtschatka to Ceylon, Egypt to Angola (Cabot, Uhler, Schafer, A. E. S.).

44. *Pantala hymenæa* Say.

Libellula h. Say, Jour. Ac. Phila. viii, p. 18, 1839. *P. h.* Hagen, Syn. Neur. N. A., p. 142, 1861.

Greenish, with dark brown markings. Hind wings with anal margin yellowish, and a *round dark brown anal spot* veined with yellow, apices sometimes smoky.

Abd. ♂ 30-32, ♀ 31-31.5. H. w. ♂ 39-42, ♀ 42.

One male, Fairmount Park, Phila., H. D. Coyle, park guard, through C. W. Johnson (C.).

Pennsylvania, Indiana, Illinois, South Dakota, Texas, N. Mexico, Mexico, Cuba (Truman, Cockerell).

29. **Tramea** Hagen.

Hagen, Syn. Neur. N. A., p. 143, 1861. Kirby, Trans. Zool. Soc. Lond. xii, p. 268, 1889.

45. **Tramea carolina** Linné.

Libellula c. Linné, Cent. Ins. p. 28, 1763. *T. c.* Hagen, l. c. p. 143, 1861.

Reddish brown; 8-10 with a broad, black, dorsal band. Extreme base of front wings yellowish; basal third of hind wings *brown* with yellow veins, a clear spot at middle of anal margin.

♂. Sup. app. *as long as* 9 + 10. Hamule *hardly if ever longer* than genital lobe.

♀. Vulvar lamina *not quite as long as* 9, bilobed in its apical three-fourths.

Abd. ♂ 31.5-34, ♀ 32-34.5. H. w. ♂ 41-44, ♀ 41-44.5.

Two males, May 26, June 10, Phila., S. F. and E. M. Aaron (A. E. S.).

Massachusetts to Florida. Brauer (Verh. z.-b. Gesell. Wien, xiv, p. 162) mentions one male of *T. carolina* from New Caledonia.

46. **Tramea lacerata** Hagen.

T. l. Hagen, Syn. Neur. Syn. N. A., p. 145, 1861.

Brownish black; 2-7 with a dorsal greenish spot. Extreme base of front wings dark brown; basal fourth or fifth of hind wings *violet-black*, whose outer margin is very ragged, a clear spot at middle of anal margin.

♂. Sup. app. *as long as* 8 + 9 + 10. Hamule *shorter* than genital lobe.

♀. Vulvar lamina *half as long as* 9, bilobed almost to base, apices of lobes emarginated.

Abd. ♂ 34-38, ♀ 35.5. H. w. ♂ 40-46, ♀ 46-47.

Two males, June 24, July 15; one pair in copula May 26, Phila., S. F. Aaron (A. E. S., C.). Tinicum Is., Sept. 4, 1888, P. P. Calvert.

Pennsylvania, Maryland, Michigan, Illinois, Missouri, Texas, Mexico, Sandwich Is. (Cabot, Kirby).

30. **Libellula** Linné.

Linné, Syst. Nat. i, p. 543, 1758. Hagen, Syn. Neur. N. A., p. 150, 1861 (in part). *Leptetrum*, *Belonia*, *Holotania* Kirby, Trans. Zool. Soc. Lond., xii, pp. 286, 288, 1889.

A. Basal half to third of the wings blackish brown for the entire width or nearly so.
♀ *with lateral margins of 8 not produced.*

47. **Libellula basalis** Say.

L. b. Say, Jour. Ac. Phila., viii, p. 23, 1839. *L. luctuosa* Burm., Hagen, Syn. Neur. N. A., p. 152, 1861.

Blackish brown; a mid-dorsal thoracic stripe and a stripe on each side of dorsum of 2-9, yellow. Wings with *basal half to third blackish brown*, outer edge of the brown frequently margined with chalky white; apex sometimes brown. Pterostigma *black*. Thorax and abdomen of old males pruinose.

Abd. ♂ 28-31, ♀ 26-27.5. H. w. ♂ 37-41, ♀ 37-39.

Abundant around Phila., June 1—Sept. 10; ovipositing July 3.
New York and Ontario to Virginia, west to South Dakota, Kansas and Texas (Cheney, Truman, Owen, A. E. S.).

B. No brown basal band of the entire width of the wings.

a. Wings unspotted at base; pterostigma unicolorous, red or yellow. ♀ with lateral margins of 8 produced ventrally ("perfoliate").

Libellula auripennis Burmeister.

L. a. Burm., Handb. Ent. ii, p. 861, 1839. Scudder, Proc. Bost. Soc. N. H. x, p. 191, 1866.

Yellowish (teneral), through yellowish brown to red; a mid-dorsal yellow thoracic stripe (teneral); abdomen posteriorly with a mid-dorsal black stripe. Wings with a *yellowish or reddish tinge*, especially along front margin, extreme apex sometimes brownish. Pterostigma *yellow or red*.

Abd. ♂ 34.5–40, ♀ 31–36.5. H. w. ♂ 36–43, ♀ 36–41.5.

On and near the sea-coast from New York to Texas; Ohio, Cuba, Isle of Pines.

b. Wings with dark basal markings, when present, in the form of a narrow streak confined to the space between the subcostal and median veins; pterostigma blackish brown, or bicolored, yellow and blackish brown. ♀ with 8 perfoliate.

Libellula plumbea Uhler.

L. p. Uhler, Proc. Ac. Phila., 1857, p. 87. Hagen, Syn. Neur. N. A., p. 157, 1861.

Frons and lips yellowish brown or olive. Thoracic dorsum and a stripe on second lateral suture, reddish brown; a median dorsal thoracic stripe and the sides yellow. Abdomen yellowish, a mid-dorsal stripe on 2–10. Wings with front margin yellowish, a *brown basal streak* between subcostal and median veins out to the first or second antecubital. Pterostigma *yellow, darker at distal end*.

♂. Face and labrum blackish brown, thorax and abdomen pruinose dorsally, in older males.

♀. Apex of wings *from beneath the pterostigma* dark brown.

Abd. ♂ 31, ♀ 29. H. w. ♂ 36–38.5, ♀ 38–39.

New York to South Carolina (Beutenmüller, Skinner, L. O. Patterson, C.).

48. Libellula cyanea Fabricius.

L. c. Fabr., Syst. Ent. p. 424, 1775. *L. quadrupla* Say, Jour. Ac. Phila., viii, p. 23, 1839. Hagen, Syn. Neur. N. A., p. 157, 1861.

Yellow; thoracic dorsum, a mid-lateral thoracic stripe, a mid-dorsal stripe on 2–10, brown; a yellow mid-dorsal thoracic stripe. Wings with base and front margins yellowish, a *dark brown basal streak* as in *plumbea*. Pterostigma *distinctly bicolored, inner half yellow or white, outer half dark brown*.

♂. Face and lips blackish, thorax and abdomen blue pruinose in old males.

♀. Apex of wings *from distal end of pterostigma* brown. In old females the brown encroaches much on the yellow of the thorax.

Abd. ♂ 27.5–30.5, ♀ 24.5–28. H. w. ♂ 33–37, ♀ 32–36.

Abundant around Phila., June 3—Aug. 8; 1 ♂, Sept. 10, 1891; ovipositing or in copula June 24, July 4.

Massachusetts to Virginia (Beutenmüller, Richardson).

N. B.—*Libellula flavida* Hagen (Syn. Neur. N. A., p. 156), not of Rambur, differs from *plumbea* and *cyanea* in having no dark brown basal streak to the wings; the apex of the wings in both ♂ and ♀ is barely edged with brown; pterostigma most like that of *cyanea*. Abd. ♂ 33.5–36, ♀ 31–33. H. w. ♂ 41–43, ♀ 40–41.5. Texas. The *flavida* of Rambur (Ins. Nev. p. 58) is different from *flavida* Hagen and may perhaps be identical with *plumbea*. These three forms are closely allied.

Libellula axillena Westwood.

L. a. Westwood's edit. of Drury, Ill. Exot. ii, p. 85, pl. 47, fig. 1, 1837. *L. lydia* Drury, l. c., 1773. *L. a.* Duncan, Introd. p. 292, pl. 29, fig. 1, 1840. Hagen, Syn. Neur. N. A., p. 156, 1861.

Inner margins of lateral labial lobes blackish. Thoracic dorsum reddish brown, a mid-dorsal stripe and sides yellow; a mark on second lateral suture and some near coxæ, blackish brown. Abdomen yellow, sides of 1–3, sutures and a mid-dorsal stripe on 2–10, blackish. Wings with a basal streak between subcosta and median to beyond the level of the arculus, a nodal dot, a streak confined to the first postcubital series, and the extreme apex, blackish brown. Pterostigma blackish.

♂. Anterior surface of frons and clypeus, labrum, black; frons above metallic blue. Thorax and abdomen blue pruinose in old males.

♀. Frons reddish or yellowish, above metallic blue; nasus pale green or yellow. rhinarium and labrum partly or entirely black.

Abd. ♂ 37–42, ♀ 37–38.5. H. w. ♂ 41–45, ♀ 42–42.5.

Georgia, Florida, Louisiana.

49. form vibrans (Fabricius?) Kirby, Cat. Odon. p. 29, 1890. *L. lydia* Hagen, Syn. Neur. N. A., p. 155, 1861.

Differs from *axillena* as follows: frons, clypeus and labrum white, pale green, or yellow. Usually no brown streak on first postcubital series.

Abd. ♂ 37–42, ♀ 37–38.5. H. w. ♂ 47–50, ♀ 45–47.

One male, June 10, Phila., S. F. Aaron (A. E. S.). One male, July 5, 1890, one female, July 3, 1893, Ridley Twp., Del. Co., Pa., P. P. Calvert (C.).

Pennsylvania and New Jersey to Texas.

form **incesta** Hagen, Syn. Neur. N. A., p. 155, 1861; Psyche v, p. 384, 1890. Calvert, Trans. Am. Ent. Soc. xvii, p. 34, 1890.

Differs from *axillena* as follows: ♂. Wings usually unspotted, sometimes with a small nodal spot. Labrum yellowish, face black, frons above dark metallic blue, in old males. ♀. Wings with the basal streak usually very short, extreme tips not always brownish, other wing spots wanting. Face yellowish, frons above brown.

Abd. ♂ 33–39, ♀ 31–34. H. w. ♂ 37–40, ♀ 37.5–39.

Canada to Florida (Hagen).

c. Hind wings with a dark brown, triangular, basal spot reaching backwards to the apex of the membranule. ♀ with 8 not perfoliate.

50. *Libellula exusta* Say.

L. e. Say, Jour. Ac. Phila. viii, p. 29, 1839. *L. deplanata* Rambur, Ins. Nev. p. 75, 1842. Hagen, Syn. Neur. N. A., p. 154, 1861. *L. julia* Uhler (*teste* Hagen).

Reddish brown. Thorax with an *olive or yellow antehumeral stripe*. Abdomen with a mid-dorsal black stripe. Wing-bases yellowish. Front wings with *two dark brown basal streaks*. Hind wings with a *superior basal streak* and an *inferior, triangular, basal spot* of varying size, dark brown, distal ends of these two sometimes united. Thorax and abdomen white pruinose in old males.

Abd. ♂ 22-27, ♀ 20.5-24. H. w. ♂ 27-33, ♀ 26.5-32.5.

Atco, N. J., June 4, 18, C. W. Johnson (W. I., A. E. S., C.). One female, Pa. (A. E. S.)

· Maine and Massachusetts to Vancouver's Is.; New Jersey, Pennsylvania, Georgia.

N. B.—Dr. Hagen states (Proc. Bost. Soc. N. H. xviii, p. 69), "*L. deplanata* seemed to be a dwarfish southern form [of *exusta*,] but there are differences in the genital parts, probably important enough to separate the two species." Thanks to the kindness of Mr. Samuel Henshaw, the writer has examined drawings of the appendages of male and female of *exusta* and *deplanata* contained in the Museum of Comparative Zoology at Cambridge, Mass. A comparison of these drawings with specimens in his own collection does not reveal differences constant enough to serve as specific.

51. *Libellula quadrimaculata* Linné.

L. q. Linné, Syst. Nat. i, p. 543, 1758. Hagen, Syn. Neur. N. A., p. 150, 1861.

Olive or yellowish. Humeral and second lateral thoracic sutures black with adjacent inferior brighter yellow marks; a bright yellow spot each side of 2-9. dorsum of 6-10 blackish. Wings yellow at base or along front margin, and a *small black nodal spot*; hind wings in addition with a *black, basal, triangular spot* below the submedian vein and filling the triangle, thence running obliquely to the anal margin a little beyond the apex of the membranule; this spot veined with yellow. Var. *prenubila* has a brownish cloud beneath the pterostigma. ♀ App. a little longer than 9.

Abd. ♂ 26-31, ♀ 27-31. H. w. ♂ 33-36, ♀ 34-36.

Atco, N. J., June 18, C. W. Johnson (W. I., A. E. S., C.).

Nova Scotia to Massachusetts, west to Washington and northward; New Jersey, Illinois, Utah, Wyoming; Europe (except the Mediterranean Is.), Northern and Central Asia, Asia Minor. See p. 206.

d. Hind wings at least with a longitudinal basal stripe (whose hind margin lies at least as far back as the postcosta), a nodal spot extending half across the wing, and a band crossing the wing at apex or at pterostigma—all three dark brown or reddish brown. ♀ with 8 perfoliate.

52. *Libellula semifasciata* Burmeister.

L. s. Burm., Handb. Ent. ii, p. 862, 1839. Hagen, Syn. Neur. N. A., p. 151, 1861.

Reddish brown. Thorax each side with two white or yellow stripes; a yellow spot on each side of 2-10. Wing-bases yellowish; the following *reddish brown*: the nodal spot, a *pterostigmal band*, sometimes the apices of all four, sometimes a small anal spot on hind wings; the following blackish brown: on the front wings the *apical half of the median space and the first few cells between the sectors of the arculus*, on the hind wings the basal stripe to the outer angle of the triangle. *Pterostigma reddish brown*.

Abd. ♂ 26-29, ♀ 25-28. H. w. ♂ 35-37, ♀ 34-38.

Fairly abundant around Phila., May 17—July 22.

Maine to Florida, west to Michigan and Texas.

53. *Libellula pulchella* Drury.

L. p. Drury, Ill. Exot. Ent. i, p. 115, pl. 48, fig. 5, 1770. Hagen, Syn. Neur. N. A., p. 153, 1861.

Blackish brown. Thorax each side with two stripes, a stripe on each side of 1-9 or 10, yellow. Wings with a longitudinal basal stripe between subcosta and postcosta out to beyond the triangle, a large nodal spot, and *apex, blackish brown*. *Pterostigma blackish brown*. ♂. Wings with milky spots adjacent to dark brown ones; abdomen pruinose in old males.

Abd. ♂ 32-35, ♀ 30-33. H. w. ♂ 40-43, ♀ 41-43.

Very abundant around Phila., May 30—Sept. 14; in copula or ovipositing June 18, 22, July 2, 20, 23, Aug. 16, 18.

Quebec to Georgia, west to Utah and Texas; California (A. E. S.).

N. B.—The females of *L. pulchella* and *Plathemis trimaculata* resemble each other, and are often confounded. The former is to be recognized by its larger size, its larger yellow spots on the sides of the abdomen forming a band, and by its relatively shorter pterostigma, which is three-eighths as long as the first post-cubital space, while that of *trimaculata* is one-half as long as that space.

31. *Plathemis* Hagen.

Hagen, Syn. Neur. N. A., p. 149, 1861. Kirby, Trans. Zool. Soc. Lond. xii, p. 287, 1889.

54. *Plathemis trimaculata* De Geer.

Libellula t. De Geer, Mém. iii, p. 556, tab. 26, fig. 2, 1773. *P. t.* Hagen, Syn. Neur. N. A., p. 149, 1861. *Libellula lydia* Drury, Ill. Exot. Ent. i, p. 112, pl. xlvii, fig. 4, 1770. Drury's name has a priority of three years, but as *trimaculata* is widely known as the name of this species, no change is here made.

Brown. Thorax each side with two white stripes each terminated below by a yellow spot; a white or yellow spot each side of 2-9.

♂. Wings with a longitudinal basal stripe between subcosta and postcosta as far as the triangle and clearer in the middle, a band across the wing from nodus to pterostigma, and sometimes the extreme apex, blackish brown; a chalky-white cloud below the basal stripe. Thorax (partly) and abdomen white pruinose in older males.

♀. Wings with a basal stripe as in ♂, a nodal patch reaching half across the wing and apex, blackish brown; 8 perfoliate. See note to *Libellula pulchella*.

Abd. ♂ 25.5-30, ♀ 23-24. H. w. ♂ 31-34.5, ♀ 32-33.5.

Very abundant around Phila., May 17—Sept. 9; ovipositing June 21, 24, July 2, 17.

Quebec to Florida, west to Colorado; Pacific coast from Washington to Southern California (O. B. Johnson, Davidson, Behrens, A. E. S.).

32. *Micrathyria* Kirby.

Kirby, Trans. Zool. Soc. Lond. xii, p. 303, 1889. Karsch, Berl. Ent. Zeit. xxxiii, p. 371, 1890.

55. *Micrathyria berenice* Drury.

Libellula b. Drury, Ill. Exot. Ent. i, p. 114, pl. 48, fig. 3, 1770. *Diplax b.* Hagen, Syn. Neur. N. A., p. 178, 1861.

♂. Black. Frons and vertex metallic blue, nasus with a yellow spot each side and sometimes also the lateral labial lobes: some yellow spots near the coxæ; 3-7 with a yellow or orange spot each side of dorsum; thorax and abdomen entirely dark blue pruinose in old individuals. Wings uncolored.

♀ form I. Only the extreme base of the wings yellowish. Abdomen as in ♂ but 10 yellow; vulvar lamina longer than 9, projecting, apex pointed, margins entire. Head and thorax colored as in ♂, or as in form II.

♀ form II. Wings with the extreme base and a large middle cloud yellowish or reddish brown. Frons as in ♂, but with a yellow spot each side; tip of vertex, nasus, labrum, greater part of labium, yellow. Thorax yellow, a mid-dorsal stripe, two antehumeral and five lateral stripes each side black. Abdomen black, 1-7 with a large dorsal spot and 10 entirely, yellow.

Abd. ♂ 23, ♀ I 22-22.5, ♀ II 21-22. H. w. ♂ 23-24.5, ♀ I and II 24-25.

One male, Folsom, Del. Co., Pa., July 5, 1890, P. P. Calvert (C.).

A coast species, Massachusetts to Virginia; Bahamas, Texas (Moore and Bullock, A. E. S.).

33. *Nannothemis* Brauer.

Brauer, Verh. z.-b. Gesell. Wien xviii, p. 369, 726, 1868. Kirby, Trans. Zool. Soc. Lond. xii, p. 312, 1889. Karsch, Ent. Nach. xv, p. 255, 259 (in part only), 1889.

56. *Nannothemis bella* Uhler.

Nannophya b. Uhler, Proc. Ac. Phila. 1857, p. 87. Hagen, Syn. Neur. N. A., p. 186, 1861.

Black; frons and nasus white or pale yellow, with a median quadrate black spot which is confluent with the black labrum. Vertex metallic-blue or green.

♂. Thorax and abdomen black, pruinose white in older males.

♀. Thorax with a yellow antehumeral stripe, sides yellow, with two oblique black lines. The following yellow: a transverse basal band on 2-4, a basal spot on 5-7, entire dorsum of 10. Vulvar lamina reaching apex of 10, only slightly projecting, apex rounded, entire. Wings yellowish on basal third.

Abd. ♂ 12.5-13, ♀ 11-13.5. H. w. ♂ 14.5-16, ♀ 14-16.5.

Phila., July 22, S. F. Aaron (A. E. S.). Berlin, N. J., July 17, P. P. Calvert (C.).

Ontario to Georgia.

34. **Celithemis** Hagen,

Hagen, Syn. Neur. N. A., p. 147, 1861. Kirby, Trans. Zool. Soc. Lond. xii, p. 274, 1889.

Celithemis ornata Rambur.

Libellula o. Ramb., Ins. Nevr. p. 96, 1842. *Diplax o.*, *D. amanda* Hagen, Syn. Neur. N. A., pp. 182, 183, 1861.

Yellow. Median labial lobe yellow (*amanda*) to black (*ornata*). The following black: frons above, rear of head, a broad mid-dorsal thoracic stripe, sometimes a humeral and two lateral thoracic stripes. Abdomen black, a yellow dorsal spot of varying extent on 2 or 3-7. *Hind wings* yellow at base, the following brown: an oblique stripe from submedian vein to membranule, behind it a parallel stripe of varying extent, and a spot at the triangle, which may unite with the latter stripe; sometimes a basal brown stripe between subcostal and median veins, and then the spot at the triangle united with the first mentioned oblique stripe; in the extreme individuals all the spots and stripes more or less united and darker. Thorax and abdomen of old males entirely black.

Abd. ♂ 17.5-22, 15.5-19. H. w. ♂ 22-27, ♀ 20-23.

A coast species, Maine to Florida.

57. **Celithemis elisa** Hagen.

Diplax e. Hagen, Syn. Neur. N. A., p. 182, 1861.

Yellow (teneral) to red; the following black: median lobe and inner edge of lateral labial lobes, a mid-dorsal thoracic, a humeral and two lateral stripes. Abdomen black, a basal dorsal spot on 2 or 3-7 and sides of 1-3, yellow or orange. *Front wings* yellowish at base and along front margin; antecubitals, median space, nodus and front side of triangle with dark brown spots; a larger spot (sometimes almost absent) between nodus and pterostigma, and the apex, dark brown. *Hind wings* similar, spot at the triangle extended to base (= first oblique stripe + spot at triangle of *ornata*), and an anal spot (= second oblique stripe of *ornata*) which may or may not unite with the spot at the triangle. Pterostigma yellow or red.

Abd. ♂ 19.5-22.5, ♀ 18.5-20.5. H. w. ♂ 25.5-27.5 ♀ 23-26.5.

Three males, Phila., June 2, 10, S. F. Aaron (A. E. S.). Berlin, N. J., July 17, P. P. Calvert. Clementon, N. J. (W. I.).

Canada to Georgia; Michigan, Illinois.

58. **Celithemis eponina** Drury.

Libellula e. Drury, Ill. Exot. Ent. ii, p. 86, pl. 47, fig. 2, 1773. *C. e.* Hagen, Syn. Neur. N. A., p. 147, 1861.

Reddish yellow. Thorax with a mid-dorsal and two lateral stripes blackish. Abdomen black, an elongated mid-dorsal spot on 2 or 3-7, sides of 1-3, yellow or orange. Wings yellowish, veins yellowish. *Front wings* with a patch from the arculus to the triangle, a nodal band (which may be broken into an anterior and a posterior spot), a band at inner end of pterostigma, and sometimes the apex, blackish brown. *Hind wings* similar, patch extended to base (= first oblique stripe + spot at triangle of *ornata*) and sometimes outwards to nodal band, and a large spot near anal angle (= second oblique stripe of *ornata*). The size of the wing-markings varies greatly. Pterostigma yellow or red.

Abd. ♂ 24-28, ♀ 21-26. H. w. ♂ 31-35.5, ♀ 31-34.5.

One male, Phila., July 22, S. F. Aaron (A. E. S.). One male, on Delaware River opposite Eddystone, Pa., July 28, 1886, P. P. Calvert (C.).

United States east of the Rocky Mts., Cuba.

35. *Leucorhinia* Brittinger.

Britt., Sitzb. Ak. Wiss. Wien, 1850, iv, p. 333. Hagen, Trans. Am. Ent. Soc. xvii, p. 229, 1890.

59. *Leucorhinia intacta* Hagen.

Diplax i. Hagen, Syn. Neur. N. A., p. 179, 1861. *L. i.* Calvert, Trans. Am. Ent. Soc. xvii, p. 39, pl. v, figs. 1, 7-9, 1890. Hagen, *l. c.* p. 235, pl. x, figs. 6, 8, 15, 16, 23, 1890.

Blackish. Labrum white or yellow; an orange or yellow dorsal spot on 2-7 (only on 7 in old individuals). Front wings with two very short basal streaks, hind wings with a short, superior, basal streak and an inferior, triangular, basal spot, blackish.

♂. Inf. app. *bifid*, its branches *divergent, pointed*. Anterior lamina each side with *an elevated black tubercle covered with small spines*.

♀. Vulvar lamina forming two *slender, separated lobes*; *two small ventral palps* on the middle of 9.

Abd. ♂ 21-22, ♀ 20-22. H. w. ♂ 23.5-25, ♀ 25-26.5.

Two males, Phila., June 17; one male, Bristol, Pa., June 16, S. F. Aaron (A. E. S.). One female (others seen), Ridley Twp., Del. Co., Pa., July 3, 1893, P. P. Calvert (C.).

Canada to Pennsylvania, west to South Dakota; Nevada, Washington.

36. *Diplax* Charpentier.

Charp., Lib. Eur. p. 12, 1840. Selys, Ann. Soc. Ent. Belg. xxxii, p. 134, 1888. *Sympetrum* Newman, Ent. Mag. i, p. 511, 1833. Kirby, Trans. Zool. Soc. Lond. xii, p. 276, 1889.

A. No additional transverse carina on 4.

a. ♂. Sup. app. with a prominent, inferior, median tooth, on whose basal side are 5-8 denticles. ♀. Vulvar lamina bifid.

60. *Diplax rubicundula* Say (Pl. II, fig. 5).

Libellula r. Say, Jour. Ac. Phila. viii, p. 26, 1839. *Diplax r.* Hagen, Psyche v, p. 385, 1890.

Yellowish (teneral) to red; lateral margins of 3-10, especially near apices, black. Legs black, femora paler inferiorly. Extreme base of wings yellowish.

♂. Genital hamule with *a little more than the apical third bifid*, internal (anterior) branch slightly longer, its apex more acute and slightly bent towards the external branch; external (posterior) branch *twice as wide* as the internal. Genital lobe projecting no farther ventrally than the external hamular branch, *not* widened towards apex.

♀. Vulvar lamina not elevated, bifid, lobes approximate, small, rounded to pointed at tips.

Abd. ♂ 21.5-25, ♀ 19.5-24.5. H. w. ♂ 22-28, ♀ 22.5-27.5.

Very abundant around Phila., July 1—Sept. 20.

Nova Scotia to Maryland, west to Lake Superior and Illinois.

Var. **assimilata** Uhler (Proc. Ac. Phila. 1857, p. 88, *Libellula a.*) has the basal half of the wings yellowish.

Abd. ♂ 22.5-27, ♀ 22-25. H. w. ♂ 25-29.5, ♀ 24.5-28.5.

One male, Ridley Twp., Del. Co., Pa., July 3, 1893, P. P. Calvert. One male, Westville, N. J., Aug. 27, 1892, P. Nell (C.).

New Jersey to South Dakota and Nebraska.

Diplax obtrusa Hagen (Pl. II, fig. 6).

D. c. Hagen, Stet. Ent. Zeit. xxviii, p. 95, 1867; note after *D. rubicundula* Syn. Neur. N. A., p. 177, 1861.

Differs from *rubicundula* as follows: ♂. Genital hamule with *apical fourth bifid*, branches proportionally shorter, external branch at least *four times wider* than internal branch. ♀. Apparently not distinguishable from that of *rubicundula*.

Abd. ♂ 22-25, ♀ 23.5-24. H. w. ♂ 21-25, ♀ 23-25.5.

Nova Scotia to Pennsylvania, west to Wisconsin; Colorado, Washington (Sheraton, J. P. Moore, Mrs. Slosson, E. M. Aaron, G. Miller, Owen, Mich. Agr. Coll., Col. Agr. Coll., O. B. Johnson).

b. Sup. app. with no prominent inferior tooth, but with 4-9 inferior denticles, of which the most apical is largest. ♀. Vulvar lamina entire.

61. Diplax semicineta Say (Pl. II, fig. 3).

Libellula s. Say, Jour. Ac. Phila. viii, p. 27, 1839. *D. s.* Hagen, Syn. Neur. N. A., p. 176, 1861.

Yellowish (teneral) to reddish brown; lateral margins of 3 or 4-10, and sometimes a mid-dorsal stripe on 8 and 9, black.

♂. Front wings with *basal half to third*, hind wings with *basal half, yellowish or brown*, clearer at extreme base. Hamule *bifid in its apical half*, internal (anterior) branch slightly shorter, slender, *more erect*, slightly hooked at tip, which is acute; external (posterior) branch two to three times stouter, its tip less acute, bent slightly outwards and backwards. Genital lobe projecting ventrally a little farther than external hamular branch, *slightly wider towards apex*. Legs black, first femora paler inferiorly.

♀. Wings yellowish at basal half, or only as far as the triangle. Vulvar lamina very short, projecting but slightly, margin entire.

Abd. ♂ 17-24, ♀ 19-23.5. H. w. ♂ 21-27, ♀ 23-26.5.

Two males, Phila., July 15, S. F. Aaron (A. E. S.). Two males, one ♀, Ridley Twp., Del. Co., Pa., July 3, 1893, P. P. Calvert (C.).

Maine to Maryland; Colorado, New Mexico, Nevada, California (Beales, Cockerell, Hillman, A. E. S.).

N. B.—The specimens of *semicincta* from Nevada, Colorado and California, have black stripes on the humeral and lateral thoracic sutures, which are absent in those from Pennsylvania.

62. *Diplax vicina* Hagen (Pl. II, fig. 4).

D. v. Hagen, Syn. Neur. N. A., p. 175, 1861.

Yellowish (teneral) to red; lateral margins of 3-9, and frequently a mid-dorsal stripe on 8 and 9, blackish brown. Extreme base of wings yellow. Legs yellowish to reddish.

♂. Hamule *bifid in its apical two-thirds*, branches of nearly equal length, *both almost erect*, internal (anterior) branch more slender, apex acute; external branch two to three times wider, *apex rounded*. Genital lobe projecting slightly farther ventrally than the hamule.

♀. Vulvar lamina *distinctly projecting*, its margin entire.

Abd. ♂ 20.5-23.5, ♀ 20.5-23.5. H. w. ♂ 22-25, ♀ 21.5-24.

Very abundant around Phila., July 11—Oct. 26, and probably later; in copula or ovipositing Aug. 31, Sept. 3, 10, 19, 21, Oct. 11, 12, 24.

Maine to Virginia; Ontario, Illinois (Miss Wadsworth, Harvey, Richardson).

B. An additional transverse carina on 4.

63. *Diplax corrupta* Hagen.

Mesothemis c. Hagen, Syn. Neur. N. A., p. 171, 1861.

Olive or brown; face, *an antehumeral stripe, two lateral thoracic stripes*, white or yellow. Abdomen yellowish, spotted with white and brown, 8-9 with a mid-dorsal black spot. Wing-veins yellowish. Pterostigma yellow, brown in the middle. Legs black, femora and tibiae with *a superior yellow stripe*.

♂. Hamule with *apical third bifid*, internal branch short, slender, apex acute, curved outwards to form a hook; external branch *twice as long, much thicker*, directed outwards and backwards, apex blunt. Genital lobe projecting a little farther ventrally than the external hamular branch. *Sup. app.* yellow, thickened in their apical half, with a row of 9-14 inferior, black denticles.

♀. Vulvar lamina *not projecting*, apex *emarginated*.

Abd. ♂ 24.5-28.5, ♀ 25-29. H. w. ♂ 27.5-31, ♀ 28-32.

One male, Folsom, Del. Co., Pa., Oct. 3, 1889, P. P. Calvert (C.). Pennsylvania; Illinois to California, Montana to Mexico; Ochotsk.

37. *Perithemis* Hagen.

Hagen, Syn. Neur. N. A., p. 185, 1861. Kirby, Trans. Zool. Soc. Lond. xii, p. 273, 1889.

64. *Perithemis domitia* Drury.

Libellula d. Drury, Ill. Exot. Ent. ii, p. 83, pl. 45, fig. 4, 1773. *P. d.* Hagen, l. c. p. 185, 1861.

Yellowish brown. Thorax sometimes with two lateral yellow stripes of varying width. Abdomen with some yellow marks.

♂. Wings brownish yellow, sometimes a dark reddish brown spot near the outer angle of the triangle, sometimes a short, basal, brown streak on hind wings. Pterostigma reddish brown.

♀. Front wings with a patch near the outer angle of the triangle and a ragged nodal band, brown. Hind wings similar, the patch larger, prolonged at its hind end and turned inwards towards the anal angle. Front and hind wings with brown markings bordered with yellow, sometimes a brown basal streak in the subcostal space. Pterostigma yellowish brown.

Abd. ♂ 13-15, ♀ 11-14.5. H. w. ♂ 16-19, ♀ 14.5-19.5.

Common around Phila., June 17—Aug. 31,

United States east of the Mississippi River; Texas, Argentine Republic, West Indies.

N. B.—Kirby (Cat. Odon. p. 10) holds that *tenera* Say is the proper name of this species found in the U. S., and that *domitia* Drury is distinct. It is here preferred to follow Dr. Hagen, who regards *tenera* and many other names as synonyms of a very variable species—*domitia*. Thus females from Florida have the hind margin of all the wings narrowly edged with brown from the nodal band to the apex, and the nodal band and the patch on the triangle sometimes confluent.

38. *Mesothemis* Hagen.

Hagen, Syn. Neur. N. A., p. 170, 1861. Kirby, Trans. Zool. Soc. Lond. xii, p. 303, 1889.

65. *Mesothemis simplicicollis* Say.

Libellula s. Say, Jour. Ac. Phila. viii, p. 28, 1839. *M. s.* Hagen, l. c. p. 170, 1861.

Bright green; thorax frequently with mid-dorsal carina, antehumeral, humeral and two indistinct lateral lines, and some marks near the coxæ, black; 1-3 mostly green, 4-10 with a mid-dorsal black band on apical half, or 8-10 entirely black.

♂. Sup. app. *yellow*. Thorax and abdomen entirely blue pruinose in old males.

♀. Vulvar lamina erect, triangular, entire.

Abd. ♂ 26-33, ♀ 23-29.5. H. w. ♂ 27-35, ♀ 31-33.

Common around Phila., June 10—Aug. 8; ovipositing June 17, 22, July 26.

United States east of the Rocky Mts., Mexico, West Indies, Bahamas (Fox and Johnson, Moore and Bullock).

39. *Pachydiplax* Brauer.

Brauer, Verh. z.-bot. Gesell. Wien, pp. 368, 722, 1868. Kirby, Trans. Zool. Soc. Lond. xii, p. 305, 1889.

66. *Pachydiplax longipennis* Burmeister.

Libellula l. Burm., Handb. Ent. ii, p. 850, 1839. *Mesothemis l.* Hagen, Syn. Neur. N. A., p. 173, 1861.

Blackish brown. Face white, frons above and vertex metallic blue. Thorax with a short antehumeral stripe, a transverse stripe in front of the antearlar sinus, and frequently the mid-dorsal carina, yellowish; sides pale green with three brown stripes.

♂. Abdomen blackish, often pruinose, sides of 1-3 yellowish, or similar to that of ♀ (teneral). Wings yellowish at base, especially the hind wings, which have two longitudinal, dark brown basal streaks; a yellowish or brownish cloud frequently present between nodus and pterostigma, apices sometimes smoky. The extent and intensity of the wing coloring vary greatly, even in specimens of the same locality at the same time.

♀. Abdomen widened at tip, black, a pale green or yellow longitudinal stripe on each side of dorsum of 2-7, sides of 1-5 yellowish. Vulvar lamina prolonged (so that the vulva lies on the middle of 9), emarginated in the middle. Wings yellowish at extreme base, no streaks or clouds. Abdomen occasionally pruinose in old females.

Abd. ♂ 20-28, ♀ 20.5-25. H. w. ♂ 23-33.5, ♀ 28-32.

Common around Phila., June 10—Sept. 4; ovipositing June 14.

Massachusetts to Florida, west to the Mississippi; Bahamas (Moore and Bullock), Texas, Mexico, Montana, California, Vancouver's Is.

PART III.

A SUMMARY OF THE PHILADELPHIA ODONATE FAUNA.

SCOPE OF THIS CATALOGUE.

The species whose names are numbered in Part II have been certainly observed within a radius of twenty miles from the Philadelphia City Hall. This arbitrary limit has been fixed by the fact that the observations upon which this paper is based have been mainly confined to the region indicated. The unnumbered species may, from what is now known of their distribution, hereafter be found in this district. The Odonate fauna of Philadelphia is, therefore, here considered to consist of the following species:

Subfam. CALOPTERYGINÆ (4 sp.)

1. *Calopteryx maculata*
2. *C. dimidiata*, race *apicalis**
3. *Hetærina americana*
4. " *tricolor**

Subfam. AGRIONINÆ (19 species).

5. *Lestes forcipata*
6. " *rectangularis*
7. " *inequalis*
8. *Argia putrida*

- | | |
|---|--------------------------------------|
| 9. " violacea | Subfam. CORDULINÆ (6 species). |
| 10. " tibialis | 37. <i>Didymops transversa</i> * |
| 11. " apicalis | 38. <i>Macromia tæniolata</i> * |
| 12. " bipunctulata | 39. " illinoensis* |
| 13. <i>Nehalennia irene</i> * | 40. <i>Epicordulia princeps</i> * |
| 14. " posita | 41. <i>Tetragoneuria cynosura</i> |
| 15. <i>Amphiagrion saucium</i> | 42. <i>Somatochlora lepida</i> * |
| 16. <i>Enallagma durum</i> * | |
| 17. " civile | Subfam. LIBELLULINÆ (24 species). |
| 18. " divagans* | 43. <i>Pantala flavescens</i> * |
| 19. " exsulans | 44. " hymenæa* |
| 20. " signatum | 45. <i>Tramea carolina</i> * |
| 21. <i>Ischnura verticalis</i> | 46. " lacerata* |
| 22. " Ramburii | 47. <i>Libellula basalis</i> |
| 23. <i>Anomalagrion hastatum</i> | 48. " cyanea |
| | 49. " axillena form <i>vibrans</i> * |
| Subfamily GOMPHINÆ (7 species). | 50. " exusta |
| 24. <i>Gomphus abbreviatus</i> * | 51. " quadrimaculata |
| 25. " exilis | 52. " semifasciata |
| 26. " minutus* | 53. " pulchella |
| 27. " plagiatus | 54. <i>Plathemis trimaculata</i> |
| 28. " villosipes | 55. <i>Micrathyria berenice</i> * |
| 29. " vastus* | 56. <i>Nannothemis bella</i> |
| 30. <i>Dromogomphus spinosus</i> | 57. <i>Celithemis elisa</i> |
| | 58. " eponina* |
| Subfamily AESCHNINÆ (6 species). | 59. <i>Leucorhinia intacta</i> |
| 31. <i>Epiæschna heros</i> | 60. <i>Diplax rubicundula</i> |
| 32. <i>Fonscolombia vinosa</i> † | 61. " semicincta |
| 33. <i>Gomphæschna furcillata</i> var.
antiloqe* | 62. " vicina |
| 34. <i>Aeschna juncea</i> var. <i>verticalis</i> | 63. " corrupta* |
| 35. " constricta | 64. <i>Perithemis domitia</i> |
| 36. <i>Anax junius</i> | 65. <i>Mesothemis simplicicollis</i> |
| | 66. <i>Pachydiplax longipennis</i> |

Of those species marked with an asterisk (*), only five individuals or less, are known from within the twenty-mile radius.

SEASONAL DISTRIBUTION (Imagos).

The species of Odonata which appear first in the year around Philadelphia are *Anax junius*, *Ischnura verticalis* and *Nehalennia posita*. The earliest date recorded for them is May 1, but they are probably to be found still earlier. From the data contained in Part II, it appears that the number of species to be found on any one day increases from 3 to 14 during May, from 14 to 32 during June, decreases from 32 to 23 during July, from 22 to 21 during

† On Sept. 18, 1893, the writer took one ♂ and saw another of *vinosa* by a brook in Springfield Twp., Del. Co., Pa.

August, and from 20 to 5 during September. The species which continues to fly latest into the Autumn is *Diplax vicina*, having been observed up to October 26, and probably to be found still later, as Mr. G. D. W. Williamson has taken it at Dobb's Ferry, New York, on November 8. The maximum number of species on the wing at any one time is thus 32 from June 24 to July 1.

TABLE SHOWING THE SEASONAL DISTRIBUTION OF THE SUBFAMILIES OF THE ODONATA OF PHILADELPHIA.

SUBFAMILY.	Earliest appearing species.	Latest appearing species.	Maximum number of species at one time.
Calopteryginae.....	Calopteryx maculata May 24.	Heterina americana Sept. 23.	Two, Aug. 11-17.
Agriioninae.....	I. verticalis, N. posita May 1.	I. verticalis, Oct. 16.	Thirteen, June 28- July 4.
Gomphinae.....	Gomphus exilis, May 24.	Gomphus plagiatus, July 17.	Four, June 22-26.
Aeschninae	Anax junius, May 1.	Aeschna constricta, Oct. 18.	Four, Aug. 28-29.
Cordulinae	D. transversa, May 13.	Epicordulia princeps July 1.	Three, June 18.
Libellulinae	P. trimaculata, L. semifasciata, May 17.	Diplax vicina, Oct. 26.	Thirteen, July 5-22.

GEOGRAPHICAL DISTRIBUTION.

Of the 33 genera represented in the foregoing list, 8 (*Dromogomphus*, *Gomphæschna*, *Didymops*, *Epicordulia*, *Tetragoneuria*, *Platthemis*, *Nannothemis*, *Pachydiplax*) are exclusively Nearctic, 8 (*Heterina*, *Amphiagrion*, *Anomalagrion*, *Epiæschna*, *Micrathyria*, *Celithemis*, *Perithemis*, *Mesothemis*) are confined to the New World, 3 (*Calopteryx*, *Fonscolombia*, *Leucorhinia*) are restricted to the Palæarctic and Nearctic provinces, while the remaining 14 are more widely distributed.

The great majority (49) of the sixty-six species of the preceding list are confined to the Alleghenian subdivision of the Nearctic zoögeographical province, *i. e.* to that portion of the United States east of the Rocky Mountains. Of the remainder—

Pantala flavescens is a well-known cosmopolitan species.

Aeschna juncea and *Libellula quadrimaculata* are diffused throughout the northern hemisphere.

Ischnura Ramburii, *Anomalagrion hastatum*, *Anax junius*, *Pantala hymenæa*, *Celithemis eponina*, *Perithemis domitia* and *Mesothemis simplicicollis* are also West Indian.

Lestes forcipata, *Anax junius*, *Libellula quadrimaculata*, *Diplax semicincta* and *D. corrupta* also occur in the region between the

Rocky Mountains and the Sierra Nevada. Except the single male cited on p. 264, *D. corrupta* is not known to occur east of Illinois.

Aeschna constricta, *Anax junius*, *Libellula exusta*, *L. quadrimaculata*, *Plathemis trimaculata*, *Diplax corrupta* and *Pachydiplax longipennis* are found on the Pacific coast of North America. *Tramea lacerata* is reported from the Sandwich Is.

The Philadelphia district is at present the northernmost known limit, east of the Allegheny Mountains, of the following ten species: *Heterina tricolor*, *Argia tibialis*, *A. apicalis*, *A. bipunctulata*, *Gomphus minutus*, *G. plagiatus*, *Gomphæschna (furcillata) antilope*, *Macromia teniolata*, *Tramea lacerata* and *Libellula (axillena) vibrans*. It is the southernmost known limit in the same region of the following five species: *Lestes inequalis*, *Enallagma divagans*, *Gomphus abbreviatus*, *G. villosipes* and *Libellula quadrimaculata*.

Synonymic Changes Introduced in Part II.

Gomphæschna antilope Hag. = var. *furcillata* Say. *Aeschna verticalis* Hag. = var. *junceae* L. *Ae. crenata* Hag. (eremita Scud.) = *clepsydra* Say. *Epophthalmia georgina* Selys = ? *Macromia illinoensis* Walsh. *Libellula deplanata* Ramb. = *exusta* Say. *Celithemis amanda* Hag. = *ornata* Ramb. *Diplax assimilata* Uhler = var. *rubicundula* Say.

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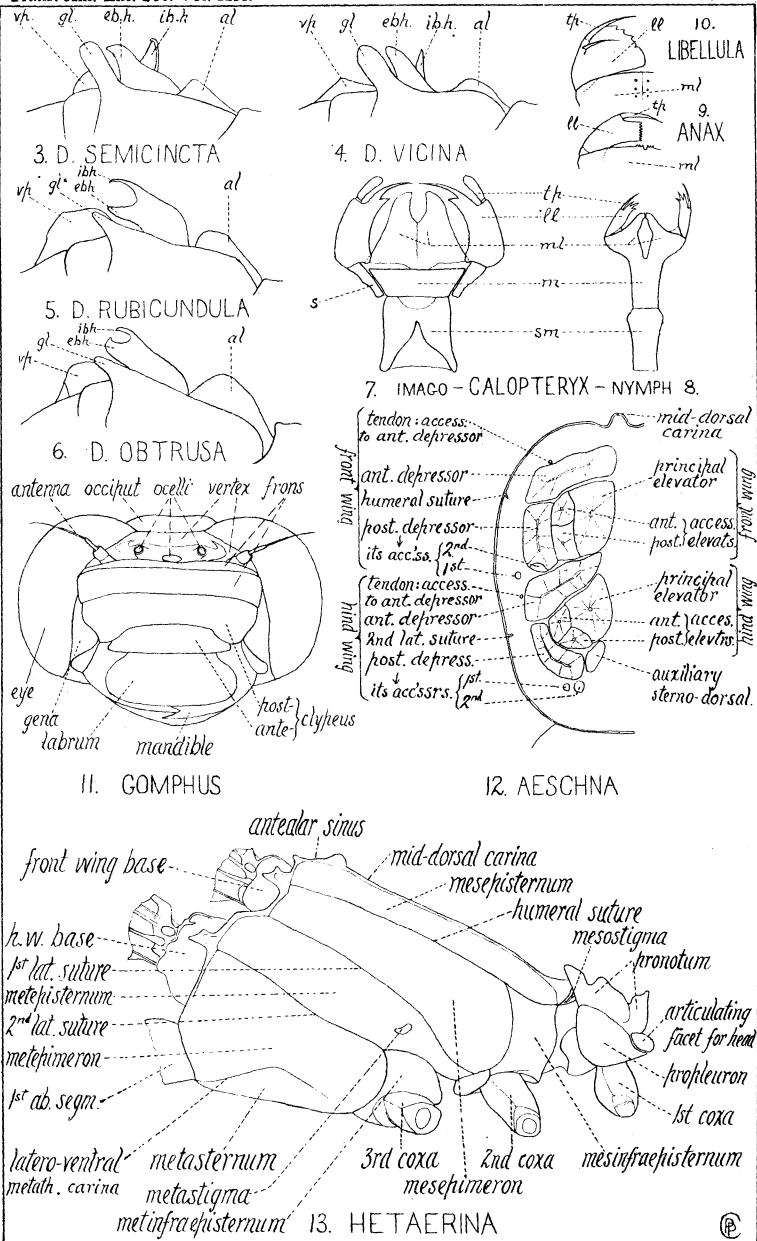
EXPLANATION OF PLATES.

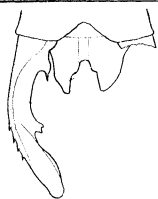
PLATE II.

- Figs. 3-6. Profile views, left side, of the external genital organs on the ventral surface of the second abdominal segment of the males of *Diplax semicincta*, *vicina*, *rubicundula* and *obtrusa*. Seen when the insect is turned upside down. *al* anterior lamina, *ibh* internal and *ebh* external hamular branch, *gl* genital lobe, *vp* vesicle of the penis.
Fig. 7. Labium of imago, ♂ of mature nymph of *Calopteryx maculata*. *sm* submentum, *m* subglossa?, *ml* median lobe, *ll* lateral lobes, *tp* terminal palp, *s* half of mentum?
Figs. 9, 10. Half of the front portion of labium of very young nymphs of *Anax junius* and *Libellula pulchella*. Letters as before.
Fig. 11. Front view of head of *Gomphus exilis*.
Fig. 12. A nearly horizontal section of the thorax of *Aeschna constricta* showing the wing muscles.
Fig. 13. Right side of the thorax of *Heterina americana*.

PLATE III.

- Figs. 14-21, 24 Dorsal views of terminal abdominal appendages of the males of various species of *Lestes*. The right superior appendage is omitted.
Figs. 22, 25. Dorsal views of the superior appendages of males of *Enallagma Hageni* and *divagans*.
Figs. 23, 26-32. Profile views right side, of the terminal abdominal appendages of the males of various species of *Enallagma*.

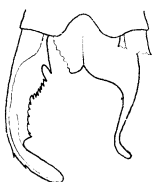




14. L. EURINA



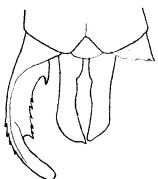
15. L. CONGENER



16. L. UNGICULATA



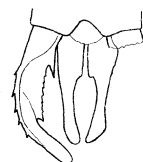
17. L. VIGILAX



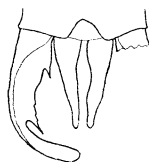
18. L. UNCATA



19. L. DISJUNCTA



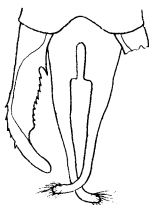
20. L. FORCIPATA



21. L. RECTANGULARIS



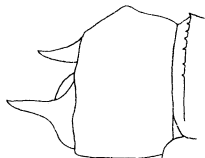
22. E. HAGENI



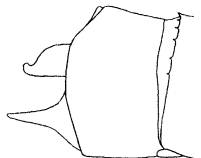
24. L. INEQUALIS



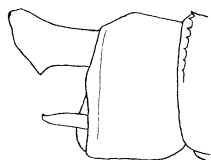
25. E. DIVAGANS



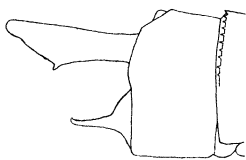
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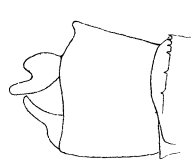
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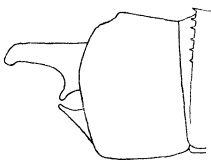
27. E. POLLUTUM



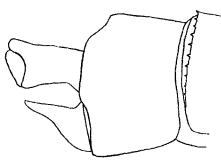
28. E. SIGNATUM



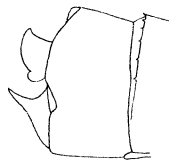
29. E. EXSULANS



30. E. ASPERSUM



31. E. CIVILE



32. E. DURUM

LESTES

ENALLAGMA